IN-STEP: The Evaluation of the First Year

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The Inquiry Based Science and Technology Education Program (IN-STEP): The Evaluation of the First Year

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Acknowledgments

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I. Introduction

This is the first report on the evaluation of the Inquiry Based Science and Technology Education Program (IN-STEP), an innovative and ambitious science education initiative being undertaken by a public-private partnership in Thailand. The IN-STEP project is being sponsored by MSD Thailand and supported by funding from its parent company, Merck & Co., Inc., and is being led and implemented by a public-private partnership of organizations committed to improving science education in Thailand. In response to the tsunami disaster in 2004, Merck and MSD Thailand donated US$500,000 to design and implement a science education program in the tsunami-affected province of Phang-nga. Managed by the Kenan Institute Asia, IN-STEP draws heavily on the experience and resources of the Merck Institute for Science Education (MISE), founded by Merck in 1993 to improve student performance in science in the United States. MISE’s efforts have shown that the use of well-designed materials and inquiry methods not only raises children’s achievement in science, but also their engagement and enthusiasm.

This report has three aims: first, to share the IN-STEP model with a broad audience of science educators and policymakers; second, to provide baseline information on the teachers and schools involved in the project; third, to provide the IN-STEP team with useful feedback from the first year of implementation. These multiple purposes result in a rather lengthy report. We hope that readers will be forgiving and seek out the parts of the report that most interest them. Most of all, we hope they will be enticed to follow the progress of IN-STEP over the next few years and learn from this effort to adapt strategies used successfully in the United States to improve teaching and learning for use in Thailand.

What Is IN-STEP?

IN-STEP is intended to improve teaching and learning in science in Thai lower secondary schools. The project has six key components:

- Carefully designed and tested curriculum modules organized around guided investigations that illuminate key concepts in the biological, physical, and earth sciences. Each module provides 6-8 weeks of instruction. Originally developed and used in the

United States, the modules have been translated into Thai and adapted for use in Thailand in grades 7, 8, and 9.

- Intensive professional development experiences for teachers that introduce them to the scientific concepts and investigations in each module. Teachers will receive training in the use of one new module each year for three successive years.

- Development of teacher leaders and local capacity to provide professional development through the use of accomplished teachers to design and deliver the IN-STEP workshops and through the training of accomplished teachers to mentor other teachers.

- Support for teachers as they implement the modules from mentors and newly developed teacher networks intended to foster instructional improvement in science over time.

- Activities designed to build student and community interest in science such as annual science days and science camps that bring scientists and adults using science together with students to conduct projects focused on community problems.

- Careful documentation of the implementation to provide feedback to the IN-STEP team members to help them improve the training and implementation as well as an analysis of the impact of the project on student performance in science, interest in science, and pursuit of science in upper secondary school.

A central goal of IN-STEP is the introduction of inquiry and associated habits of mind into Thai classrooms through the use of the guided investigations in the modules. Inquiry is a fundamental aspect of science, and of science education, and it is a central tenet of IN-STEP. Inquiry is a systematic intellectual process that great philosophers including Aristotle and Buddha and prominent scientists including Thomas Edison and Marie Curie used to gain increased understanding of the world around them and develop new knowledge. All too often, however, the teaching of science in schools overlooks the inquiry process in order to ensure that students learn “science facts” that can be used to score well on examinations, or the inquiry process is trivialized into a mechanistic set of procedures—the seven-step scientific method— rather than emulating the complex process of investigation, examination of evidence, and reasoning and modeling that characterizes the actual work of scientists. The failure to engage students in serious inquiry limits their capacity to understand and “do” science, and ultimately reduces their interest in, and access to, careers that depend on scientific knowledge. Lack of experience with scientific inquiry and lack of scientific understanding also limit the ability of citizens to apply disciplined, rational thinking to their personal lives and to their assessments of their country’s science and technology initiatives. Therefore, it is critical for Thailand, and for other nations, to improve science teaching by incorporating the inquiry process as a means of helping individual students and their communities understand and cope with rapid change and the demands of global competition. Data on the performance of Thailand in science relative to other Asian nations are presented in Appendix A.

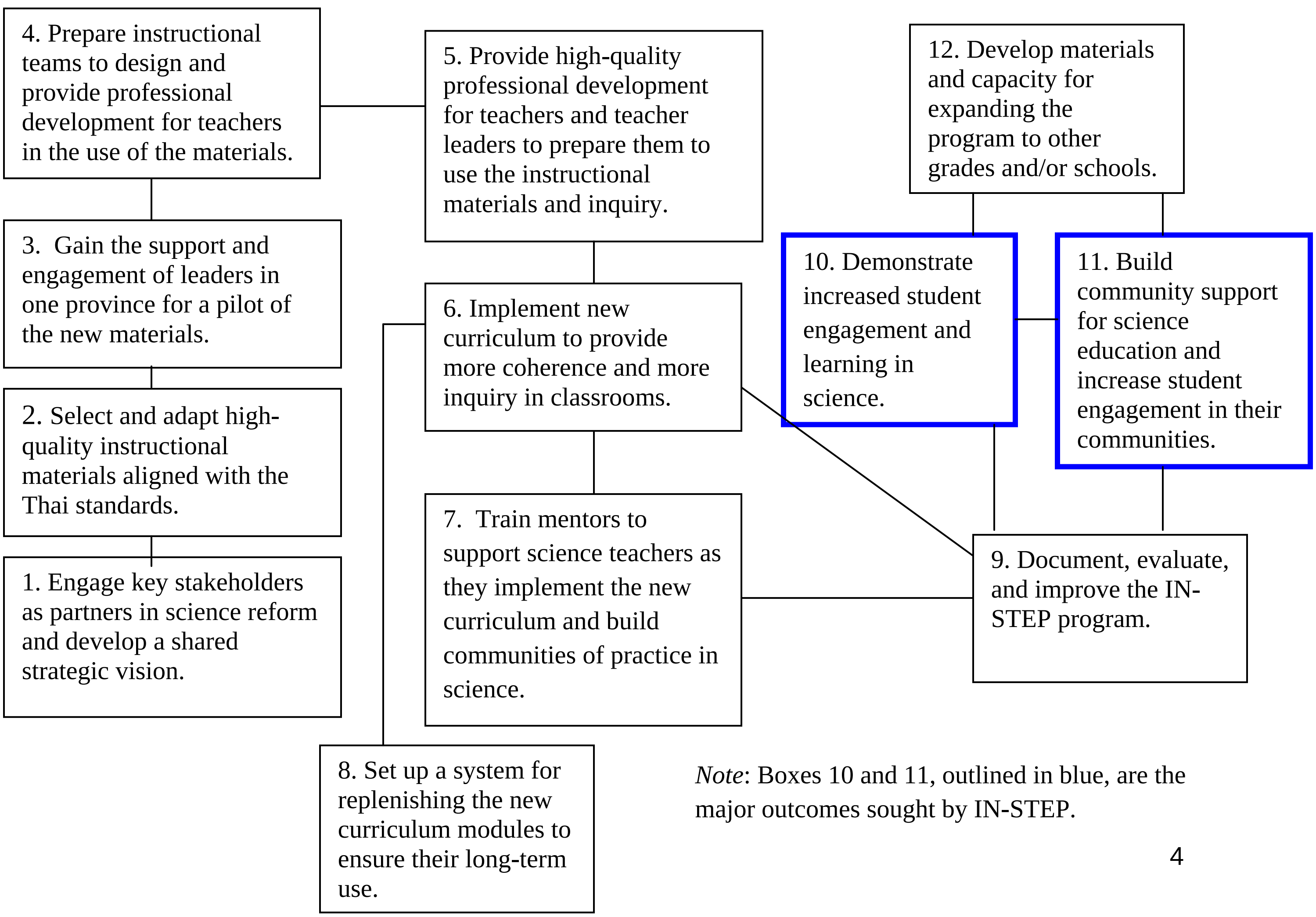
II. The IN-STEP Theory of Action

The design of IN-STEP is based on the same theory of action that has guided the work of MISE in the United States. This theory involves 12 major elements that are outlined in Figure 1. The first nine elements are already being implemented by IN-STEP and the final three elements will be addressed as evidence of the effectiveness of the design is collected over the next two years. Each of the 12 elements is discussed briefly below.

1. **Collaborative Design**. IN-STEP is a collaboration among numerous agencies including MSD-Thailand, MISE, the Kenan Institute Asia (K.I.Asia), the Thai Ministry of Education (MOE), the Institute for the Promotion of Teaching Science & Technology (IPST), the National Science and Technology Development Agency, the Science Society of Thailand, and major universities. Representatives of these organizations have worked together to develop a shared vision of good science teaching and have reached agreement on the IN-STEP design. By involving key stakeholders in advisory committees both at the national and provincial level, significant support has been generated for IN-STEP. At the operational level, the IN-STEP team includes professionals drawn from K.I.Asia, MISE, MOE, IPST, Teachers College, Columbia, and Thai universities.

2. **Well-Designed Instructional Materials**. These same partners collaborated on the selection of carefully designed and tested instructional materials that emphasize guided inquiry and are aligned with Thai national standards. With support from MISE, K.I.Asia obtained the rights to use, translate, and adapt selected science curriculum modules developed by the National Science Resources Center in the United States. Known as the Science and Technology for Children (STC) materials, each module is organized around a major topic in science, such as light, and contains 4-8 weeks of lessons that are designed to build student understanding and include investigations that provide opportunities for students to apply concepts and do science. The modules contain all of the equipment and materials that are needed to teach the lessons and conduct the investigations. The translated and adapted versions of the selected modules serve as the foundation for IN-STEP.

Figure 1. The IN-STEP 12-Step Theory of Action to Improve Science Teaching and Learning



Note: Boxes 10 and 11, outlined in blue, are the major outcomes sought by IN-STEP.

3. **Local Engagement**. The IN-STEP team selected the province of Phang-nga as the site for the pilot program because of the impact of tsunami on the area and the need for accelerated economic development. Team members have worked closely with provincial leaders to build understanding and support for the program, and the provincial educational leaders have played a key role in gaining participation of principals and teachers and in setting up the infrastructure to support IN-STEP.

4. **Tapping Expertise in Content and Classroom Practice**. Accomplished Thai science teachers and content experts from universities and education agencies have been invited to serve on the IN-STEP instructional teams charged with designing intensive module-based institutes for teachers. Each institute is based on one of the curriculum modules. MISE staff have led an annual design retreat to support the work of these instructional teams and have led the teams in design and delivery of the initial round of institutes.

5. **Curriculum-Based Professional Development**. Beginning in 2007, lower secondary science teachers (grades 7, 8, and 9) in Phang-nga were invited to participate in intensive professional development for at least three years. Each participating teacher is being prepared to teach three modules selected for their grade level. To enable them to make the required changes in their teaching practice, they attend an institute focused on one new six-week science unit module each year. The instructional teams design and lead these institutes at which teachers review and apply the science concepts in the modules, participate in the investigations that they will later use with their students, and learn to use inquiry-centered instruction.

6. **Implementation Support**. IN-STEP has set clear expectations for administrators and teachers in participating schools that the new instructional materials and strategies should be fully implemented as designed and offers support for implementation from mentors and teacher networks.

7. **Developing Science Leaders**. Members of the instructional teams and other accomplished science teachers have volunteered to serve as mentors to the teachers implementing IN-STEP, and these mentors have been provided with training. The training and experience provided for instructional team members and mentors are

expected to contribute to the development of instructional leaders in science at the provincial and school levels who will possess expertise in the curriculum content and the capability of providing training and on-site support for other teachers. IN-STEP also is encouraging the development of professional learning communities in science by networking science teachers, by engaging teachers in common tasks such as assessing student work, developing lessons, and mentoring new teachers, and by implementing science camps. The IN-STEP mentors are convening teacher meetings in local areas and the Educational Service Area Office (ESAO) plans to organize meetings for teachers, that it is hoped, will provide the basis for the development of learning communities. These activities will build the capacity of the province to sustain the use of the new curricular materials and ultimately create capacity to expand IN-STEP to other provinces.

8. **Ensuring Sustained Use of the Materials**. The curricular modules contain materials that are used up in the course of conducting investigations and, for those modules to be used again, these materials must be replenished. To ensure that the modules continue to be used and that they are replenished in a cost-effective manner, the provincial education office has worked with K.I.Asia to set up a system for collecting, replenishing, and distributing the modules. Without this support, modules might be cannibalized for materials and eventually cast aside as schools failed to replenish them because of inadequate budgets or the difficulty of ordering replacement materials. The provincial resource center will help ensure that the investment in the modules continues to pay dividends over time.

9. **Formative and Summative Evaluation**. An evaluation team is providing regular feedback to the developers to improve the implementation and effectiveness of IN-STEP, and a rigorous impact study will be conducted to demonstrate its impact on teaching and learning. IN-STEP has engaged researchers from CPRE at Teachers College and the Institute for the Promotion of Teaching Science and Technology (IPST) to work together with K.I.Asia staff to conduct a timely and rigorous evaluation. In addition to documenting the use of the IN-STEP materials and their effects on student learning, IN-STEP will track the students' choices of subjects in high school and their participation in, and success at, carrying out projects that contribute to the improvement of their

communities' economic development. The involvement of Thai researchers in the evaluation also will contribute to their capacity to conduct future implementation studies.

10. **Clear Indicators of Success**. The activities and resources described above are part of a coordinated strategy to improve student learning in science and create more positive attitudes among students about science, science learning, and science careers. The key indicators of success for IN-STEP will be increases in the number of students pursuing science studies in upper secondary schools, improved performance on national and international assessments in science, increased participation in science competitions, and more positive attitudes toward science among students and community leaders.

11. **Community Engagement and Support**. IN-STEP seeks to increase community support for science education and to enhance student motivation to study science by providing activities that bring educators, students, and community members together to do science. Community members, teachers, and students have enjoyed the province-wide science day events led by MSD volunteers. Students have been invited to participate in science camps where they learn how to apply their science knowledge to projects that are relevant to their local contexts. These will be annual events in the province. The IN-STEP team will document and share student projects aimed at contributing to the improvement of the quality of life in their communities. Community members with special expertise are being recruited to share their knowledge and provide continued support for students. By engaging staff from national parks, local universities, and private organizations in designing and implementing the science camps, IN-STEP will leverage the expertise and resources in the local area to help build a true learning community in science.

12. **Developing Capacity to Sustain and Scale the Reforms**. A major goal is to develop capacity to expand the program to other schools in other provinces and to other grade levels and to share the strategies, and evidence of their effectiveness with leaders at all levels—school, provincial, and national—in order to create support for expansion of the program if warranted by the evidence. Over three years, IN-STEP will develop a cadre of experienced trainers and mentors who will be capable of extending the program to other provinces without external assistance. IN-STEP also has provided opportunities for staff from MOE and IPST to participate in the training.

This is the IN-STEP plan. It is a plan based on research and experience in the U.S context, but it is being implemented in a different setting, a setting in which the resources, practices, beliefs, and values differ. And while the model has been adapted to fit Thailand, experience may reveal that further adjustments are needed to produce the results that IN-STEP's designers aspire to achieve. This is why the model is being piloted in one province, and why it is being carefully evaluated.

Year One (2007) in Brief: Building the IN-STEP Partnership

While the design work began in late 2006, the first full year of the project was 2007. Once MSD Thailand, MISE, and the Kenan Institute Asia had agreed on the broad parameters of IN-STEP, the next step was to develop a broader partnership. Obtaining commitment and engagement from provincial and national government leaders and leading science educators were the first critical steps. After conducting a series of face-to-face meetings with leaders in science education and establishing an advisory board and technical working groups to provide mechanisms for partners to participate, IN-STEP gained strong support from the Ministry of Education, the Institute for the Promotion of Teaching Science and Technology (IPST), the governor of Phang-nga, directors and educational supervisors from the provincial education office in Phang-nga, and principals, master teachers, and teachers from Phang-nga schools.

The next step was to secure inquiry-based curriculum materials. MISE found a willing partner in the National Science Resources Center (NSRC), a joint venture of the Smithsonian Institution and the National Academy of Sciences in the United States. NSRC had developed a set of curriculum modules known as Science and Technology for Children (STC) that were widely used in the United States and also in other countries. NSRC granted K.I.Asia the right to translate, adapt, and use these materials in Thailand. A group of Thai science educators including senior representatives from MOE and IPST attended an NSRC strategic planning workshop and reviewed the materials, selecting nine modules that matched the Thai standards for the lower secondary grades. Their recommendations were reviewed and approved by MOE, IPST, and MISE. K.I.Asia arranged for the translation and adaptation of the teacher and student manuals and other materials in the modules. The initial modules being included in IN-STEP are listed in Appendix B.

To engage local stakeholders and students, IN-STEP organized a Fun Science Day in partnership with the Educational Service Area Office of Phang-nga in September, 2006, to introduce inquiry-based learning using fun science games, a mobile planetarium, and science experiments. A total of 360 students from 48 schools in Phang-nga attended the event.

Following the MISE model, the IN-STEP team recruited accomplished science teachers and science educators to serve as members of the instructional teams that would develop and deliver the workshops for teachers. These teachers taught the modules in their classrooms to gain first-hand experience with the materials. In October, 2006, these teachers and their principals attended a workshop on inquiry, followed by a design retreat led by MISE staff that allowed the instructional team members to gain more experience with the modules and investigations and then to plan workshops for the teachers.

After nine months of preparation, IN-STEP was officially launched on March 26, 2007, with the signing of a Memorandum of Understanding by the representatives of the Ministry of Education's Office of the Basic Education Commission (OBEC), The Institute for the Promotion of Teaching Science and Technology, MSD (Thailand) Ltd., and the Kenan Institute Asia.

Immediately following the launch ceremony, the first IN-STEP professional development workshop was conducted for 43 participating science teachers from 22 schools in Phang-nga. The five-day workshop was conducted by 18 accomplished teachers who worked with six instructional team leaders from MISE.

The MISE staff worked closely with their Thai counterparts to provide effective learning experiences for the 43 participating teachers, allowing them first to experience the inquiry process themselves by conducting the investigations in a module and then to practice how to engage their students in these same investigations. After the completion of the training, some members of the instructional teams provided continuing assistance to their fellow teachers by serving as mentors, helping them with the use of modules and with the improvement of their science teaching.

"This workshop is very different from other workshops I have attended throughout my whole life," said Ajarn Jedsada Sriwiset, science teacher and academic head of Kho Yao Wittaya School. "I have learned many techniques which are impressive and very valuable." After 20 years of teaching and participation in many workshops, Ajarn Jedsada said that he had "learned a lot in different way," noting, "I did not quite understand why I did not get the answer right away until I realized that it is not the answer that is important, but the process of finding out the answer." He added that he would apply what he learned to his students. "It's very important to ask the right question at the right time and let students to think about it rather than tell them the answer right away."

Year Two (2008) in Brief: Initial Implementation

In 2008 IN-STEP will be expanded, and another cadre of 45 teachers will be prepared to teach one of the original three curriculum units—one each for grades 7, 8, and 9—and the original 43 teachers will attend workshops preparing them to teach a new module for their grade level. Instructional teams have met to revise and deliver workshops for the original three units, as well as to design workshops for the three new units. These six workshops will be offered to teachers in April, 2008. Implementation of the new curriculum units will again be supported by volunteer mentors, electronic communications and tools, and provincial teacher meetings.

It is hoped that IN-STEP will become a model for Thailand for the improvement of Thai students' performance in science. In the long term, IN-STEP's goal is to contribute to Thailand's international competitiveness in science and technology. Ultimately, with this higher capability, the Thai people will be able to apply their knowledge of science and technology to preserve the country's natural resources and to live in harmony with nature.

III. The Evaluation of IN-STEP

The Consortium for Policy Research in Education (CPRE) at Teachers College, Columbia University, has been asked to lead the design and conduct of an evaluation of IN-STEP. CPRE includes researchers from seven universities in the United States, and the IN-STEP evaluation team includes researchers from two of these institutions, Teachers College, Columbia University, and the University of Pennsylvania. The CPRE researchers are collaborating with research staff from K.I.Asia and IPST to conduct the evaluation.

The central questions to be answered by the evaluation are these:

- What is the impact of the IN-STEP curriculum materials and training on teachers' classroom practice?
- What is the impact of the changes in practice on student learning in science?
- What factors affect the implementation, sustainability, and spread of the IN-STEP concept of good science teaching?

There are three major tasks facing the evaluation team: (1) documenting the instructional team retreats and the teacher workshops to give timely feedback to MISE and K.I.Asia staff and the IN-STEP instructional teams; (2) documenting the use of the modules by the teachers participating in IN-STEP and obtaining feedback from these teachers to help K.I.Asia and MISE strengthen the program and ensure full implementation; and (3) assessing the impact of IN-STEP on teachers' classroom practice and on student learning in science. These three tasks are discussed here in reverse order.

The Impact Evaluation. Measuring the impact of IN-STEP requires overcoming four serious challenges. First, the evaluation team must identify a reliable measure of science learning that is sensitive to the content of the IN-STEP modules. Second, this test must be administered by all of the participating schools in a consistent manner. Third, the team must estimate the effects on student learning without using a comparison group because it appears to be difficult (but not impossible) to construct a credible matched comparison group of classrooms or schools given the limited data available nationally on students in Thailand. Finally, the evaluation team must persuade stakeholders to be patient as the modules must be fully implemented before a good measure of the effects of IN-STEP can be obtained. Since teachers are only implementing one six-week module per year, the effects of IN-STEP are likely to be modest in the first and second years, even if everything has gone well. By the third year, some teachers will be using three modules, which will constitute about 20 weeks of instruction or about half of the school year, and it would be reasonable to expect observable effects on learning.

The best answer to the first two questions would be to use the 9th grade national science test, but there is no reason to believe that this test will contain sufficient items on the content covered by the IN-STEP modules to be sensitive to the effective use of the modules. As an alternative, IPST has offered to develop a science assessment for use in Phang-nga that will be sensitive to this content. This test will provide a good measure of the impact of the program on student learning. This will solve the first two problems described above. The third problem will be addressed by examining differences across students in the province who have been exposed to one, two, or three modules or none of the modules, which will allow the CPRE researchers to develop relatively rigorous estimates of the effects of the program. The fourth problem will be addressed by providing stakeholders with good data on implementation in 2007, 2008, and 2009 while reminding them that the impact evaluation will be forthcoming.

Feedback on Implementation. Tracking implementation is normally labor-intensive and therefore relatively costly. Inexpensive approaches such as teacher surveys that rely wholly on self-reporting are notoriously biased as the respondents often know what answers are desired and provide the socially acceptable response. But measuring the degree of implementation is important both for the impact analysis and for providing feedback to the training teams to improve the program. The evaluation team has proposed three ways of doing this that are relatively inexpensive. First, the follow-up mentors have been asked to file site-visit reports for each school, which will provide answers to some basic implementation questions. Since they are already visiting the schools, this will not be an added burden. Concerns about error introduced by favoritism will be addressed by comparing these reports to the results from telephone interviews with a sample of teachers. Concerns about workload for the mentors are being addressed by keeping the forms simple.

A second approach to measuring classroom implementation is to conduct telephone interviews with teachers during the period in which they are using the modules. The IPST volunteers and K.I.Asia staff conducted these interviews this year. CPRE staff provided training and assisted with the development of protocols and coding of the data. With additional assistance from CPRE, K.I.Asia staff have entered these data into Atlas Ti and analyzed the data for this report. Similar interviews will be conducted in the Summer and October, 2008, but after the number of teachers increases in 2009, only samples will be interviewed. Similar interviews were conducted with the IN-STEP mentors, and these data also were analyzed for this report. These interviews will be repeated in 2008.

A third option would be to conduct a survey of the teachers, and if a survey is used in the future, it will be used in conjunction with site visit reports and interviews in order to make adjustments resulting from teachers' tendency to overestimate their use of reform practices.

Documenting the Training. This has been the most straightforward part of the evaluation. The interviewers from K.I.Asia and IPST who were trained by CPRE staff to conduct teacher interviews also asked questions about the workshops. Again, CPRE staff helped with the protocols and with the coding of the data. In addition to this, participants in both the instructional team retreats and IN-STEP workshops were asked to fill out simple surveys at the end of these experiences. The data collection efforts and the response rates are displayed in Table 1. Note that with the exception of the reports from the mentors, the response rates are uniformly high.

Table 1. Data Sources for the IN-STEP Evaluation

Source	Total Participants	Response Rate
Survey at Instructional Team Retreat, October 2006	28	93%
Interviews With Teachers at IN-STEP Workshop, March 2007	43	100%
Survey of teachers at IN-STEP Workshop, March 2007	43	100%
Survey of Mentors, Mentor Training, June 2007	18	100%
Survey of Mentors, Mentor Training, October 2007	17	100%
Telephone Interviews With Teachers, October 2007	43	100%
Reports From Mentors, October 2007	17	53%

Organization of the Report

This is the first report produced by the evaluation team, and presents baseline data collected in the first year plus some initial analyzes that might provide insight into how to strengthen the program, especially the supports for implementation, and what the challenges are likely to be in the coming two years. The data sections are organized in five parts. Section IV focuses on the characteristics of the schools and teachers participating in IN-STEP so far. Section V examines the composition and experience of the instructional teams who serve as the designers and instructors for the teacher professional development. Section VI examines how various participants—teachers, instructional team members, and mentors—perceive and assess the preparation they have received from IN-STEP. Section VII presents data on the use of the curriculum materials by the first cadre of teachers. Section VIII examines the experience of the mentors in their initial efforts to support teachers. And Sections IX and X summarize the impact of IN-STEP to date as well as the findings from this first round of data collection, discuss the challenges that lay ahead, and offer some recommendations to the IN-STEP partners.

IV. The IN-STEP Schools and Teachers

In this section we take a look at the schools and teachers who are participating in IN-STEP and report some baseline information that might help us account for the observed patterns of participation and implementation reported on in Sections VII. What are the primary characteristics of the schools and teachers who have volunteered to participate in IN-STEP, and how do they vary? With respect to the schools, we look at their location, their size, the nature of their professional communities, and the past performance of their students in science. With respect to the teachers, we examine their age, preparation in science, recent professional development, why they are participating and their expectations, and who they go to now for support in science.

The Schools. Fifty-three schools serve lower secondary students in Phang-nga. The map in Appendix C shows where the schools are located in the province. While few of the schools can be described as isolated, they are scattered across a large area. Given the shape of the province, traveling from the north to the south of the province takes about 2½ hours. This makes it difficult to call a meeting in a central location and expect all of the teachers or principals to show up. When teacher meetings are held, they must be organized regionally to limit the amount of travel for participants.

Table 2. Enrollment in Lower Secondary Schools: First-Year Participants and Schools Province-Wide

Enrollment in Grades 7-9 (Number of students)		Schools Sending Teachers in Year 1	All Schools in the Province
Small School	< 120 students	3	27
Medium School	121 – 300 students	10	17
Large School	301 – 600 students	3	3
Very Large	> 601 students	6	6
Total		22	53

Source: Phang-nga Educational Service Area Office.

Regarding school size, Table 2 shows that during the first year of implementation, all nine of the large or very large schools in the province were participating in IN-STEP. This means that in the second year and third years of the pilot, more teachers from medium and small schools will join the program. Because these teachers have fewer colleagues in science—in some cases, there is only one science teacher in a school—and because they might be assumed to be more reluctant participants in that they did not volunteer in the first phase, they likely will require higher levels of support to implement the new curriculum units.

Moreover, while school size is inversely related to school performance in the United States—a finding that has led to the contemporary small-schools movement—it is the opposite case in Thailand. Small schools are usually rural schools that are under-resourced and attract poorer students, and their results on examinations reflect these conditions (Bank of Thailand, 2006).

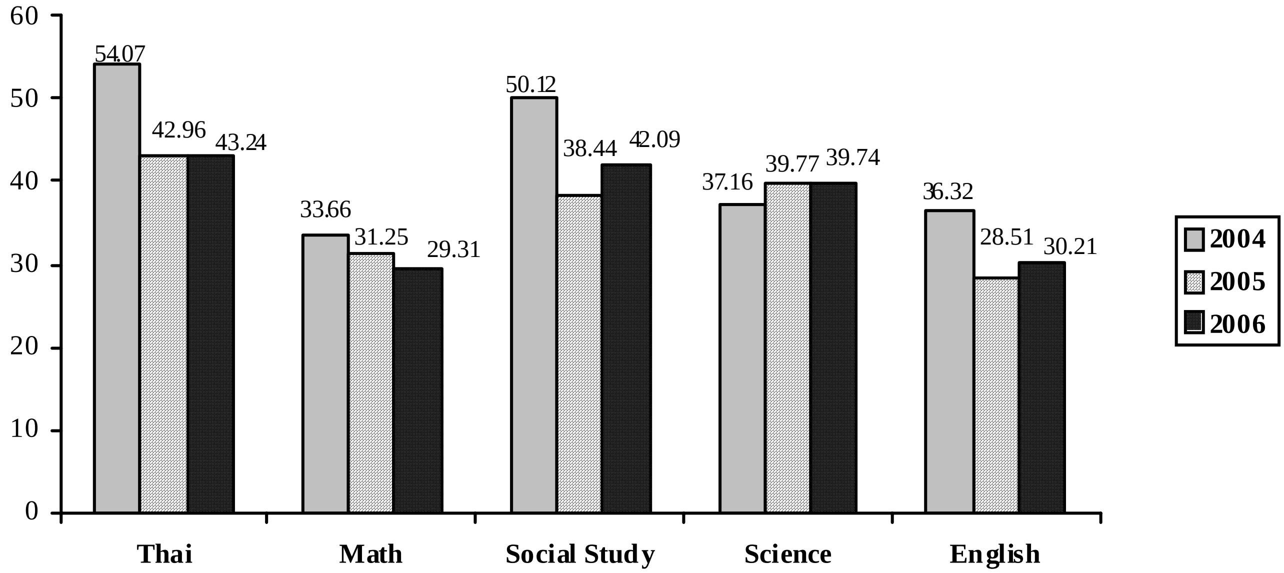
Table 3. The Average General Achievement Test (GAT) Scores of 9th Grade Students in Phang-nga: Compared With National Scores, 2003-2006

	2003		2004		2005		2006	
Subject	**Phang-nga**	**Nation**	**Phang-nga**	**Nation**	**Phang-nga**	**Nation**	**Phang-nga**	**Nation**
Thai	54.07	53.98	54.07	38.29	42.96	-	43.24	43.94
Math	33.66	34.99	34.93	34.88	31.25	-	29.31	31.15
Social Studies	50.12	49.33	43.91	42.44	38.44	-	42.09	41.69
Science	37.16	38.07	37.93	37.22	39.77	-	39.74	39.34
English	36.32	37.92	31.34	32.27	28.51	-	30.21	30.85
Average	-	-	37.28	37.02	36.19	-	36.92	37.39

Source: Phang-nga Educational Service Area Office.

The GAT scores of Phang-nga students are comparable to the national averages in all subjects. This means that the schools in Phang-nga are rather representative of schools in Thailand as a whole, and this makes the province a good place to pilot new curricula. This is especially true in terms of student performance in science. From Tables 3 and 4, it is clear that performance trends in mathematics and science in the province have not shown any improvement from 2004 to 2006. In fact, mathematics performance has declined relative to national performance.

Table 4. Comparison of GAT Scores 2004-2006 of 9th Grade Students in Phang-nga



Source: Phang-nga Educational Service Area Office.

The data in Table 5 show that the schools currently participating in IN-STEP represent a rather broad distribution of achievement. The national average score on the GAT 9th grade science test in 2006 was 39.34, so students in the high and medium-high performing schools are scoring on average above the national average on the test, and those in the other two categories are scoring below the national average.

Table 5. School-Level Performance on the 9th Grade GAT Science Assessment

Performance Categories	Schools Sending Teachers in Year 1	All Schools in the Province
High (GAT score >45)	4	9
Medium-High (40-44.99)	7	10
Medium-Low (35-39.99)	7	22
Low (<35)	4	10
Totals	22	51*

**Note*: Missing data for two schools.

Table 6. Distribution of IN-STEP Teachers
by Level of Faculty Participation (Penetration) and School Size

Participation in IN-STEP	Size of the Schools				
	Small	Medium	Large	Very Large	Total
All science teachers in the school	1	3	0	3	7
50% or more	3	10	5	3	21
Less than 50%	0	3	3	9	15
Total	4	16	8	15	43

Source: March, 2007, teacher interviews.

From the data presented in Table 6, we see most of the participating teachers are from school settings where other teachers are participating in IN-STEP. As more teachers enroll from small schools, this will be less likely to be the case. This suggests that the IN-STEP team should consider the merits of alternative rollout strategies. We discuss these in Section X.

Table 7. Teachers' Perceptions of Principal Support
for Teaching and Learning in Science

Principals' Support				
	Module			
Participation	Earth in Space (EIS)	Energy, Machines, Motion (EMM)	Light (L)	Total
Highly Supported	5	8	5	18
Supported	4	2	6	12
Neutral	2	3	2	7
Unsupported	1	0	2	3
Highly Unsupported	0	2	0	2
No Response	1	0	0	1
Total	13	15	15	43

Source: March, 2007, teacher interviews.

The data on teachers' perceptions of principals' support in Table 7 are highly positive. About 70% of the participating teachers think that their principals will support them in implementing IN-STEP. For example, one respondent said, “The principal provides good support always since he has a science background. Science has a higher budget than other subjects in my school” (IN-STEP field notes, October, 2007). Another said: “Sometimes, the principal comes to observe my class. Mostly, if I request something important for teaching, I will get support” (IN-STEP field notes, October, 2007). These comments were typical, but 28% of teachers expressed concerns about how much support they were receiving or were likely to receive from their principals. They gave responses such as this: “[My] principal does not give priority on science. Mostly, he supports activities and music since it can promote school to public.” Or: “There [is] not enough equipment in science ….The principal rarely visits my class ….” (IN-STEP field notes, October, 2007). An exploration of the sources of these concerns is required in order to find effective ways to enhance principal support for IN-STEP. The relationship between the level of a principal’s support and the level of a teacher's implementation will be tracked over time, because it is anticipated that this will affect the level of initial implementation and sustainability over time.

Table 8. Teachers' Perceptions of Professional Community in Their Schools by Training Group

Level of Teacher Collaboration	**Module**			**Total**
	EIS	**EMM**	**L**	
High Collaboration	3	1	1	5
Some Collaboration	5	3	2	10
Weak Collaboration	3	9	5	17
No Collaboration	2	2	6	10
N/A	0	0	1	1
Total	13	15	15	43

Source: March, 2007, teacher interviews.

Sixty-four percent of the teachers reported that collaboration among teachers in their schools was weak. (By “weak,” we mean that teachers rarely meet formally and almost never work together on any aspect of instruction.) In fact, almost a quarter of the teachers reported that there was no communication among science teachers and some said they liked it that way. By contrast, we categorized responses indicating regular meetings and sharing of equipment and materials, but no collaboration on instruction tasks, as "some collaboration," and cases in which teachers reported frequent cooperation on lesson or unit planning, joint design of assessments and scoring of student work, and observing each other teaching as "high collaboration." These data suggest that it will be difficult to create cultures of collaboration in the schools, especially given the limited resources available for on-site support.

In our judgment, it might be wiser for the IN-STEP team to focus on developing teacher networks in several regions of the province. While it will be challenging to develop an effective mechanism for supporting sustainable networks that fit with local schools' cultures, it could be critical for sustaining the use of the modules and inquiry methods. In many schools, there is only one science teacher teaching at each grade level, so the teacher has no colleagues who are using the same modules and therefore no one to talk to about engaging students, student misconceptions, or other problems he or she might encounter in the classroom. A network can provide this kind of support and also can serve as a means of improving practice over time as teachers share strategies that appear to be successful. The networks also will expose teachers to the benefits of collegial interaction and might contribute to changes in the school cultures themselves. Assigning accomplished teachers or mentors as lead teachers in a region, providing them with small stipends and support from principals and ESAO staff, and asking them to plan and lead teacher meetings might result in sustainable teacher networks. The main point here is that IN-STEP is not positioned to overcome the obstacles to teacher collaboration that exist in many of the schools and needs to develop an alternative strategy to support instructional change.

Table 9. Colleagues' Attitudes Toward IN-STEP

Feelings About IN-STEP Participation	Module			Total
	EIS	EMM	L	
Positive	9	9	12	30
Neutral	2	3	1	6
Negative	0	0	0	0
Mixed	2	2	0	4
N/A	0	1	2	3
Total	13	15	15	43

Source: March, 2007, teacher interviews.

The data in Table 9 show that 10 out of 43 or 23% of the teachers mentioned that their colleagues have neutral or mixed attitudes towards IN-STEP, suggesting that there is still some work to be done to make teachers aware of the benefits of IN-STEP.

The Teachers. The IN-STEP teachers are experienced. Table 10 shows that 86% of them have more than three years of teaching experience and half of them have over 10 years of teaching experience. Their age distribution is quite dispersed, covering from under 30 to over 50. It might be interesting to explore the relationship of teachers' age and teaching experience, their openness to new teaching practices, and the levels of implementation observed in their classrooms.

Table 10. Age and Teaching Experience of IN-STEP Participants

	Age				
	Under 30	**31-40**	**41-50**	**Over 50**	**Total**
Under 3 years	3	2	NA	1	6
3-10 years	5	7	1	NA	13
Over 10 years	NA	3	10	11	24
Totals	8	12	11	12	43

Source: March, 2007, teacher interviews.

All of the IN-STEP teachers majored in science at the university or teacher training college. This implies that most of them should have relatively strong content knowledge. However, as Table 11 shows, almost half of the participants majored in general science and some might be teaching out of field, for example, teaching a course in physics when their degree is in biology. So in future analyses we should examine the relationship between teachers' science background and their implementation of modules in specific domains of science.

Table 11. Teachers' Formal Science Background Content and Credentials

Field	Undergraduate Major	Graduate Degrees
Biology	6	-
Chemistry	7	-
Physics	6	-
General Science	21	-
Other	2	1
Totals	42	1

Source: March, 2007, teacher interviews.

Table 12 shows that teachers have had rather diversified professional development experiences in both science-related and nonscience subjects. While our data do not tell us the precise content of these experiences, the topics suggest a stronger emphasis on methods and technology than on science content or how students learn science. It might be interesting to explore the teachers' perceptions of the differences between their past training and IN-STEP. This will contribute to increased understanding of the methodology IN-STEP uses to develop high-quality professional development.

Table 12. Previous Professional Development of IN-STEP Teachers

Field	Number
Instructional Design (Lesson Planning)	16
Inquiry-Based Learning	6
Computer Literacy (ICT)	3
Chemistry	2
Child-Centered Teaching	2
Environmental Science	2
Instructional Media	2
None (IN-STEP is the first)	2
Other (Assessment, Biology, Curriculum and Assessment, Electronics, Geography, Management, Tsunami, and Video Production)	8

Source: March, 2007, teacher interviews.

Table 13. Nature of the Teachers' Decisions to Participate

Nature of Decision	Module			Total
	EIS	EMM	L	
Volunteered	5	8	6	19
Assigned but Willing to Attend	8	5	7	20
Assigned but Reluctant to Attend	0	2	2	4
Total	13	15	15	43

Source: March, 2007, teacher interviews.

Ninety percent of the teachers indicated that they were willing to attend the workshop (see Table 13), and over 88% of teachers (38 of 43) mentioned that they expected to acquire new teaching techniques or improve their techniques by participating in IN-STEP (see Table 14). Other frequently mentioned expected benefits included acquiring new materials and increasing science knowledge. Next year we will revisit this information to see if teachers feel they were able to meet their expectations over the two years of implementation and to probe more deeply into what really motivates teachers and works for them. We also will probe into why some teachers were reluctant to attend, and what we learn might lead to better ways to communicate about IN-STEP.

Table 14. What Teachers Expect to Gain

Expected Benefits (Number of Mentions)	Module			Total
	EIS	EMM	L	
New instructional materials	3	5	9	17
Increased personal knowledge of science	4	9	2	15
New teaching techniques	12	12	14	38
More active students	7	4	5	16
Improved student learning of science	2	4	3	9
Use of IN-STEP materials in other grades	2	2	2	6
Networking/new friends	0	1	1	1
Improved assessment strategies	0	1	0	1
Total	30	38	36	104

Source: March, 2007, teacher interviews.

From Table 15, it is clear that many teachers receive little instructional support and rely mostly on themselves. Others seek support primarily from other teachers within their school or in other schools. These data are in agreement with those from the previous table showing that support within the professional community is very low. It is noteworthy that teachers do not report principals or external experts such as university faculty as sources of support. This may be a function of how we asked the questions, and in future interviews we will explore what kind of support teachers feel they need, and what they seek from other teachers in order to properly design an effective support system. These data show that there is an opportunity for IN-STEP to provide training or a mechanism to fill an important gap.

Table 15. Sources of Instructional Support

Participation	Module			Total
	EIS	EMM	L	
Rely on myself	7	13	12	32
Lead teacher	3	4	3	10
Teachers in my school	10	9	9	28
Teachers in other schools	3	4	5	12
Other experts (university professors, etc.)	2	2	5	9
Principal	0	0	0	0
ESAO supervisors	0	0	0	0
Total	25	32	34	91

Source: March, 2007, teacher interviews.

Summary. The teachers participating in IN-STEP are generally experienced and they all majored in science at the university. They tend to work in the larger schools in Phang-nga. The majority are from schools whose performance on the GAT science test is higher than the national average. For the most part they are participating willingly in IN-STEP because they hope to improve their teaching techniques. They tend to work in isolation and report low levels of collaboration with other teachers in their schools. However, they describe their principals as being supportive of science and their participation in the project.

V. The IN-STEP Instructional Teams

In the IN-STEP project, professional development for teachers is planned and delivered by an instructional team consisting of accomplished teachers and content experts. These instructional teams typically have four to seven members who plan the workshop for a single curriculum module and then deliver the workshop for a group of 15 teachers. Some of them also serve as mentors to provide follow-up support as the teachers use the new modules. The formation of effective instructional teams depends on careful recruitment, a well-designed process of team formation and workshop design, and the engagement of team members over time to provide continuity and experience.

Recruitment. In Thailand, MISE provided staff with expertise in science and experience with the instructional team approach to lead the initial teams. K.I.Asia, with assistance from the ESAO and IPST, recruited accomplished Thai teachers and other science educators to serve on the teams. The initial teams were somewhat larger than those typically used by MISE as the level of interest in the process was quite high.

Table 16. Instructional Team Members for Cohorts 1 and 2

Categories	Year One Three Workshops	Year Two Six Workshops
MISE	3	5
Active Teachers in Phang-nga	12	24
Other Teachers	3	3
University Faculty	3	0
National Government Agency Staff	6	5
ESAO Phang-nga	3	2
Totals	30	39

Source: IN-STEP database.

Table 16 displays the background of the teams used to plan the first round of workshops (three curriculum modules/43 teachers) in March, 2007, and those who are expected to lead the second round of workshops (six curriculum modules/88 teachers) in April, 2008. It also is clear from Table 16 that the average size of the instructional teams is decreasing. This is intentional as the IN-STEP leaders found that it was awkward to have eight to 10 people on a team. There was simply not enough for them to do. In addition, the number of teachers engaged in the instructional teams is increasing, while the involvement of university and government personnel is decreasing. This has advantages and disadvantages. From the perspective of building capacity in the province to provide professional development in science and from the perspective of developing teacher leadership, it is a positive trend. But from the perspective of developing understanding of the model in national agencies and engaging the content expertise of university faculty, it is a negative trend.

Design Retreats. The instructional teams prepare for their work in a three-day design retreat, and it is there that they begin their collaborative effort to design an effective teacher workshop for the curriculum module assigned to them. So far, the MISE staff has conducted two design retreats, one in October, 2006, and another in October, 2007. At the retreat the teams are provided with expert assistance from experienced science educators and professional developers, attend sessions where big ideas in pedagogy, assessment, and learning are reviewed and discussed, and have large blocks of time to plan their own workshops.

Team members are provided with the science module that they will be working on in advance so that they can teach all or part of it in their own classrooms, and familiarize themselves with the content, the investigations, the problems students encounter, and the assessments. At the retreat, they review the module as a team, identify areas that teachers and/or students might struggle with, and begin to map out a set of experiences to be offered to teachers that will introduce them to the module and give them first-hand experience with the investigations they will eventually be asking their students to conduct. After the retreat, the teams continue their work so that they have a well-specified script for their workshop long before the time comes to deliver it.

Team members who are working on a module that was the subject of a workshop the previous year are charged with considering the feedback from the previous year's participants as well as the notes of the previous instructional team members to make revisions in the workshop script. In this manner, the workshops become more highly specified over time and hopefully more effective as they become more responsive to the needs of teachers.

Table 17 displays the instructional team members’ assessments of the preparation they received in the design retreats. While they were asked a number of specific questions about trainers, time allocations, materials, their confidence about doing the work, etc., their responses were uniformly high. This reflects both the quality of the retreats and the enthusiasm of the participants. As a consequence, we have reported only the summary scores here.

Table 17. Instructional Team Members' Ratings of Design Retreats Years 1 and 2 [Based on a Four-Point Likert Scale]

Module	Year 1 Teams N = 30	Year 2 Teams N = 39
Earth in Space	-	3.65
Energy, Machines, and Motion I	-	3.92
Light	-	3.94
Properties of Matter	-	4.00
Energy, Machines, and Motion II	-	3.64
Human Body Systems	-	3.87
Overall Average	3.33	3.84

Note: In Year One, neither the participant name nor module name was collected. In Year Two, there was information about the module name.

Continuity. Twenty-three of the 30 instructional team members involved in the first IN-STEP workshop—and 100% of the instructional team members who were from Phang-nga—voluntarily participated in the second round. This is important to the success of IN-STEP because it is this accumulated knowledge and skill that will make the program increasingly robust. It also is an indicator of the importance and quality of the program. These are busy people, and they are donating their time, so their commitment reflects their judgment that this is a worthwhile endeavor.

The instructional team approach has been used for nearly two decades in the United States by MISE and has four enormous advantages over conventional training models:

1. The overall quality of the teams is quite high as they are not dependent on a single individual. Instructional team members possess both content and pedagogical knowledge, and can share both theoretical and practical perspectives on the use of the curriculum materials. The presence of content experts offers teachers opportunities to deepen their understanding of the content and to master different ways of representing concepts for students. The presence of accomplished teachers provides insights into how the lessons

will flow in the classroom, what problems are likely to occur, and how teachers can deal with the classroom management issues that arise when students are engaged in inquiry.

2. The instructional teams provide rich opportunities for the development of teacher leadership in science. Teachers who serve on the teams deepen their content knowledge, make their tacit craft knowledge about pedagogy explicit, learn how to design effective learning opportunities for teachers, and become confident presenters and facilitators.

3. The design retreat offers an opportunity to pull the team together as a working group and, after the first year, it provides an opportunity to apply the lessons learned from the previous year and improve the training experience for teachers. The design retreat is a critical piece of the MISE model as it provides professional development for the instructional teams themselves and strengthens their capacity to work with teachers.

4. The instructional teams expand the pool of individuals qualified to lead professional development, providing the capacity for scaling up the program. Over two years, 34 Thais have served on instructional teams. By the fourth year, the number of experienced professional development leaders is likely to reach 60. This means that for each of the nine curriculum units being implemented under IN-STEP, there will be six to eight experienced trainers who could organize new teams to train in other provinces. Based on the MISE experience, two to three experienced people can be matched with two to three new trainers to create an effective instructional team, so there will be the capacity to create three instructional teams for each unit.

Summary. Using the instructional teams to design and deliver the IN-STEP workshops for teachers appears to be working as well in Thailand as it has in the United States. It has not been difficult to recruit qualified people to serve on the teams. Those recruited have been enthusiastic about the training that they have received. However, it is worrisome that the participation of university faculty and government agency staff has dropped off significantly. And, to date, the process has been led by the MISE staff. The expansion of IN-STEP over the next two years will require the recruitment of additional instructional team members and the development of local leadership for the teams.

VI. IN-STEP Professional Development

In this section, we examine the professional development provided to teachers by IN-STEP. Previously, we have described how the teacher workshops are developed. Each one is organized to introduce teachers to a particular science module. Three of these workshops were offered to teachers in April, 2007, and 43 teachers participated. In April, 2008, an estimated 88 teachers will attend six workshops, each one preparing participants to teach a different science unit. How have the participants rated these learning experiences to date?

Participant Ratings of IN-STEP Professional Development. As indicated in Table 18, the ratings from the teacher surveys conducted at the end of the workshops show that the participants thought the professional development was of very high quality. The participants were very enthusiastic about the training. One said: “It is completely new; the IN-STEP materials are very good, the best. I give 100% to IN-STEP, and the project will be better if it is expanded to other schools in other provinces.” Another expressed the sentiments of many, saying: “I think IN-STEP is the first training [I have had] in my life that I can use in the real classroom because the project provides me everything I need such as materials, handbooks.” (IN-STEP field notes, March, 2007). These responses were typical.

Many of the participants felt that IN-STEP had made them more effective teachers and made teaching easier. For example, one said:

> The training has helped me a lot, it made me aware of the right direction instead of having to plan everything by myself. IN-STEP also saves my time since I have so many assignments, and it makes me confident about teaching. Students receive better learning than from traditional style in which they just memorize the content. (IN-STEP field notes, March, 2007)

Another said: “IN-STEP has made me confident, I surely teach the right way and students are more motivated.” The teachers were particularly positive about their increased understanding of science. They made comments such as: “IN-STEP prepared me well in the content and in using both the teacher manual and the student manual, which help make learning activities easier.”

Table 18. Overall Quality of the Professional Development for Teachers

Survey Topics	Average Rating
Accomplishment of the Objectives	4.32
The Quality of the Training Activities	4.62
Confidence in Capacity to Implement	4.58
Benefit to the Participant	4.58
Overall Average	4.53

Source: Questionnaire on Professional Development, March, 2007; N = 42, Likert Scale 5.

Table 19. Ratings of the Professional Development Six Months After Training

Ratings of the Instructional Teams and IN-STEP Workshops on a 4-Point Rubric	Module			Total
	EIS	EMM	L	
The workshop provided an excellent understanding of the science content and inquiry and there was excellent support by the Instructional Team.	4	3	6	13
The workshop provided a generally good understanding of the content and inquiry and the support by the Instructional Team was adequate.	6	7	8	21
The workshop provided a fair understanding of the content and inquiry and/or the support provided by the Instructional Team was lacking in some ways.	1	4	1	6
The workshop provided a weak understanding of the content, the Instructional Team seemed to be confused, and/or the support provided was generally inadequate.	2	1	0	3
Total	13	15	15	43

Source: Telephone Interviews, October, 2007.

Table 20. Level of Confidence in Content Knowledge Six Months After Training

Self Ratings by Teachers on a 4-Point Rubric	Module			Total
	EIS	EMM	L	
Highly confident about content knowledge	6	0	2	8
Somewhat confident about content knowledge	3	7	9	19
Some lack of confidence in content knowledge	4	7	2	13
No confidence in content knowledge	0	1	2	3
Total	13	15	15	43

Source: Telephone Interviews, September, 2007.

Table 21. Level of Preparedness in Use of Inquiry Six Months After Training

	Module			
Rating on a 4-Point Rubric	**EIS**	**EMM**	**L**	**Total**
Highly confident about use of inquiry	10	6	5	21
Somewhat confident about use of inquiry	2	4	8	14
Lack confidence about use of inquiry	1	4	2	7
No confidence in use of inquiry	0	1	0	1
	13	15	15	43

Source: Telephone Interviews, September, 2007.

However, the ratings in Tables 19, 20, and 21, drawn from interviews conducted with the same teachers six months later, show that their assessments of the quality of the professional development had changed somewhat as they faced the realities of using the new curriculum materials in their classrooms. This was most noticeable in the Energy, Machines, and Motion module, the subject matter of which teachers probably had the weakest content background and reported the lowest levels of confidence in their preparedness. (See Table 20). Only six of the 43 teachers were physics majors, which might account for this falloff.

Interestingly enough, while other data (see Table 14) show that the teachers anticipated that IN-STEP would help them improve their teaching methods and learn how to use inquiry in their classroom, and did not expect the workshops to deepen their knowledge of science, in the interviews conducted while they were implementing the new curriculum, they expressed greater confidence in their skills at using inquiry (see Table 21) than they did in their knowledge of the scientific content (see Table 20). Nearly half of the respondents indicated that they were highly confident that they could use the inquiry process in their classrooms, but only one-fifth of them expressed high confidence that they could teach the science concepts in the modules.

Table 22. Improvements in Teaching

Issue	**Number**
IN-STEP makes the teacher more confident in classroom	6
Student learning has increased	6
Teaching is easier when teacher uses IN-STEP	1
Decrease in preparation time	1

Source: Telephone Interviews, September, 2007.

In the interviews, teachers also were asked what improvements they had made in their teaching as a result of participating in IN-STEP. Table 22 displays the frequency with which various improvements were mentioned in the teachers' responses. The most frequent responses were an increase in self-confidence and improved student understanding of the content. Note that only 14 of the 43 teachers responded to this item. This reflects the inexperience of the IN-STEP evaluation team in that secondary questions meant to extend and elaborate responses, provide examples, or probe deeper into a topic were sometimes neglected. As indicated in Section III, we are working to improve the interview skills of the team and the interview process. This is another aspect of IN-STEP's capacity-building agenda in that evaluation team members are learning how to use qualitative methods and how to study implementation processes.

Teachers also were asked how the IN-STEP professional development could be improved. Again they responded from the perspective of six months of experience during which time they had attempted to use the module that they had been prepared to use. Their suggestions are displayed in Table 23. The most frequent response by far was a desire for interaction with the IN-STEP team and with other teachers after the workshop. About a quarter of the teachers wanted forums where their problems could get discussed and solved and where ideas about use of the modules could be shared. This was a strong response from the Energy, Machines, and Motion teachers who also expressed the least satisfaction with their preparation and the lowest confidence in their content knowledge.

Table 23. Teachers' Suggestions for Improving Professional Development

	Module			
Suggestions	**EIS**	**EMM**	**L**	**Total**
More interaction after the PD	2	6	3	11
Better instructional material	1	1	4	6
Better project management	2	0	3	5
More time in the workshop	2	0	3	5
Better instructional team	2	0	0	2
Expand to other school/level/subject	2	0	1	3
Knowledge on assessment	1	1	1	3
Better manual	0	1	1	2
No response	3	7	4	14
Total	15	16	20	51

Source: Telephone Interviews, September, 2007.

Summary. For the most part, teachers hold IN-STEP professional development in high regard, but after some experience using the materials, some have suggestions for improving the experience. The most common suggestion is for more follow-up support. It is also clear from the data that teachers' assessment of their professional development experience varies across the modules. Some modules may require more support because of the complexity of the material, the demands of the investigations on classroom management, the science backgrounds of the teachers, or all of the above.

VII. The Use of the IN-STEP Materials and Pedagogy

In this section we look at two critical questions: Are teachers using the new instructional materials? And how are they using them? The level of use—the implementation—of the first IN-STEP modules provides us with an important leading indicator about the potential impact of IN-STEP on teaching and learning. If teachers do not use the materials, then obviously the entire program will have little impact although it could still affect teachers' pedagogical practices. And if the materials are not used as they were designed to be used, the likelihood is that there will be less impact on student learning. So where are we with implementation of the instructional materials at this point in time?

Three groups of teachers were trained in the use of one of three modules in March, 2007, but due to problems with shipping and customs, they did not receive the modules until August, 2007. Many had planned to begin teaching the modules in June and July. The late arrival of the materials meant that some of them had already begun other units and others were reluctant to begin to use the new modules for fear they would not be able to finish them before the semester ended in October, 2007. So there were further delays in implementation. These problems may have had significant impact on the level of use of the modules in this first year.

To measure implementation, we asked the teachers to describe their use of the module in an interview conducted toward the end of the period in which they were using it. We specifically asked them if they had used, or planned to use, all of the lessons in the module and if they had made any adaptations to the lessons, and to tell us about the nature of those adaptations. We then coded these interviews and grouped teachers into the following categories:

- Implementing with high fidelity, meaning that they were using all of the lessons and made only minor adaptations (adding an inquiry, extending a lesson)
- Partial implementation or implementing with major adaptations, such as making major changes in the sequence of lessons, skipping some investigations, using other materials in place of the IN-STEP material, etc.
- Selective use of materials from the module as a supplement to the old curriculum
- No implementation to date

In Table 24 we see that only 7 of 43 teachers reported implementing the modules with high fidelity, meaning with no adaptations to or omissions from the original design. This is probably less fidelity than the IN-STEP team hoped for, but it is understandable given the context, the limited experience of the teachers with instructional materials of this kind, and the delayed arrival of the materials. A more positive interpretation of the data in Table 24 is that 30 of the 43 teachers implemented the units with no or relatively small adaptations. Note the variation across the three units: Teachers using the Light unit made the largest number of small adaptations as a result of the problems they had obtaining halogen bulbs, but also had the highest overall level of implementation.

Table 24. Level of Implementation by Module

	Module			
Level of Implementation	**EIS**	**EMM**	**L**	**Total**
High (fidelity)	3	3	1	7
Moderate (adaptation or partial)	3	7	13	23
Low (selective use as supplement or limited use)	7	5	1	13
Total	13	15	15	43

Source: IN-STEP database.

Table 25. List of Adaptations by Module (Number of Mentions)

List of Adaptations	Module EIS	Module EMM	Module L	Total
Teachers change method or materials	3	3	6	12
Teachers switch the lessons or activities	0	0	2	2
Teacher cut some lessons or activities	4	5	3	12
Teachers extend time	2	2	4	8
Teachers provide additional science contents	1	0	2	3
Teachers provide additional guidelines	0	4	5	9
Total	10	14	22	46

Source: IN-STEP database.

Table 25 provides us with some insights into the nature of the adaptations teachers made. Teachers using the Light unit made the most adaptations, largely because of the problems with the light bulbs, but also added new material and more time, and provided additional guidance to students. For the most part, these were small, nonlethal adaptations—that is, they did not alter the basic design, or the content, or flow of the lessons.

Data provided by the mentors confirm the teacher self-reports on implementation. The data in Table 26, while not precisely parallel to the data in Table 24, show that nearly 90% of the teachers were using the material but that two-thirds of those had made some modifications to the units. The mentors also report that the highest number of modifications were in the Light unit. Encouragingly, the mentors report that 28 of the 31 teachers who reported using the modules said planned to use the material again the next semester. The IN-STEP team needs to probe why three teachers said they were not planning to use the units and, if their decisions cannot be justified or altered, consider whether they should be dropped from the program.

Table 26. Mentors' Reports on Observed Implementation

Teachers' Level of Implementation	Module EIS	Module EMM	Module L	Total
Number of teachers visited (mentees)	9	15	12	36
Teachers using IN-STEP module	6	13	12	31
Teachers planning to use IN-STEP again next semester	6	13	9	28
Teachers making modifications to the IN-STEP module	3	8	11	22

Source: Mentor Questionnaire October 2007. N = 14 (of 17); N of Teachers = 36 (of 43).

Problems With the Materials. Teachers reported a variety of problems with the IN-STEP materials (See Table 27). The problems varied across the modules. The teachers using the Light unit had trouble with the halogen bulbs and some of the investigations were dependent on having the bulbs. The teachers using the Energy, Machines, and Motion module reported more breakage. They also had more problems with the student and teacher manuals due to poor translations, the flow of the materials, and correlating the two manuals.

Table 27. Difficulties With Use of the Units (Number of Mentions)

	Module			
Participation	**EIS**	**EMM**	**L**	**Total**
Translation of the IN-STEP teacher manuals	4	12	4	20
Translation of the IN-STEP student manuals	1	12	4	17
Understanding the processes in the manuals	7	2	4	13
Missing or broken materials	3	9	15	27
Students' lack of confidence	1	1	3	5
Students' lack of science background	1	1	0	2
Needed to more time	0	3	2	5
Teachers' lack of assessment method	0	1	0	1
Teachers located too far from mentors	0	1	0	1
No problems reported	4	3	0	7
No response	2	1	0	3
Total	23	46	32	101

Source: Telephone Interviews, September, 2007.

Student Response to the Materials. If students respond enthusiastically to new materials, and if they demonstrate success on the assigned tasks and on teacher assessments, then teachers are more likely to continue using the material. How have students responded so far to the IN-STEP materials? The only data we have come from teacher self-reports, which might be inclined to be somewhat positively biased. Nevertheless, the data presented in Tables 28 and 29 are encouraging as they show that student engagement in the materials was generally good and for the most part students were able to master the content. However, a significant number of teachers— almost 20%— reported that student engagement was low. This may reflect the way the materials were introduced, managed, and used by the teacher. This is an area that requires on-site investigation. The data in Tables 28 and 29 also suggest that student engagement and mastery of the material were lower for the Light module than for the other two modules (Earth in Space and Energy, Machines, and Motion). Whether that has to do with the equipment problems that teachers experienced, the level of expectations of the teachers, the difficulty of the material, or the way the material was taught is not clear. Here again, there is a need for direct observation and more targeted interviews of the teachers.

Table 28. Student Engagement

	Module			
Participation	**EIS**	**EMM**	**L**	**Total**
High	4	3	1	8
Medium	5	8	7	22
Low	0	1	6	7
No response	4	3	1	7
Total	13	15	15	43

Source: Telephone Interviews, September, 2007.

Table 29. Student Performance on Teacher Assessments

	Module			
Level of Mastery	**EIS**	**EMM**	**L**	**Total**
High	4	3	1	8
Medium	6	8	7	21
Low	0	1	6	7
No Response	3	3	1	7
Total	13	15	15	43

Source: Telephone Interviews, September, 2007.

Factors Affecting Implementation. The research literature identifies a number of factors that affect teacher adoption of new practices. Most of this literature is based on studies in western countries, and often biased toward the experiences of urban schools. Among the critical variables are school size, principal support for the reforms, the level of professional collaboration in a school, the age and experience of the teachers involved, and the willingness of teachers to adopt the reforms. Here we look at how these factors appear to be affecting the implementation of the IN-STEP materials.

Table 30 displays the cross-tabulation between school enrollment and the level of implementation. The data show a statistically significant relationship between size and the level of implementation with teachers in larger schools generally implementing the modules with greater fidelity. Fisher's Exact Test can be interpreted like a chi-square test, but it does not require that the Ns in 80% of the cells be greater than 5. So in this table, the likelihood that there is a relationship between the two variables—school size and level of implementation—is greater than 99%.

Table 30. School Size and Level of Implementation

Level of Implementation	Small	Medium	Large	Totals
High fidelity	1	3	3	7
Moderate adaptation or partial	2	13	8	23
Low (use as supplement)	1	0	12	13
Totals	4	16	23	43

Note: Fisher's Exact Test p. = 0.0018. Highly significant.

In Table 31, we examine the relationship between each school's average performance on the GAT science test and implementation and find no relationship between the two variables. Given that the GAT is a fact-oriented test, this perhaps should not be too surprising. In Table 32, the relationship between teachers' perceptions of their principals' support for IN-STEP and implementation is examined, and here we also find a strong relationship. Teachers are more likely to implement the full units if they believe that their principals are supporting their effort. In western societies, this relationship is typically quite high in elementary schools where principals are expected to be instructional leaders, but weaker at the secondary levels where teachers are content specialists and principals are managers. As the amount of time devoted to IN-STEP materials increases and if the level of student engagement in inquiry increases, we might expect to see principals even more involved in decisions about the sustained use of the IN-STEP materials and see an even stronger relationship here. The increased use of IN-STEP materials will generate some pressure on instructional materials budgets as consumables have to be replaced, and some pushback from principals might be anticipated as they struggle to deal with competing demands. And students will become more active learners, and perhaps noisier, also drawing the attention of some principals. On the positive side, there will be more student work product to examine and perhaps more students involved in science fairs and science competitions. These developments also will draw the attention of principals.

Table 31. Average Performance on the GAT Science Test by School and Level of Implementation (N = 42)

Level of Implementation	Below Average Achievement	Above Average Achievement
High fidelity	2	5
Moderate adaptation or partial implementation	12	11
Low (use as supplement)	5	8

Note: Chi-square = 0.906, p = 0.6357. Not significant.

Table 32. Principal Support and Level of Implementation

Level of Implementation	Unsupportive Or Neutral	Supportive	Totals	No Response
High fidelity	1	5	6	1
Moderate adaptation or partial	8	15	23	0
Low (use as supplement)	12	1	13	0
Totals	21	21	42	1

Note: Fisher's Exact Test p = 0.000418. Highly significant.

In Table 33 we look at the age of the teachers and their level of implementation and find a weak inverse correlation. The data suggest that younger teachers were somewhat more likely to implement the full units, but show little variation among teachers over the age of 30.

Table 33. Teacher Age and Level of Implementation

Level of Implementation	Under 30	31-40	41-50	Over 50	Totals
High fidelity	3	1	2	1	7
Moderate adaptation or partial	3	9	3	8	23
Low (use as supplement)	1	5	6	1	13
Totals	7	15	11	10	43

Note: Fisher's Exact Test p = 0.1430. Not significant.

Table 34. Teachers' Decision to Participate and Level of Implementation

Level of Implementation	Voluntary	Assigned but Willing	Assigned & Reluctant	Totals
High fidelity	5	2	0	7
Moderate adaptation or partial	8	11	4	23
Low (use as supplement)	6	7	0	13
Totals	14	7	21	42

Note: Fisher's Exact Test p. = 0.3358. Not significant.

In Table 34 we find no statistical relationship between voluntary participation and the level of implementation. This might be due to the confounding of two categories—voluntary and assigned but willing; that is, many individuals in the second category might have attended voluntarily if they had the opportunity to do so.

Table 35. School Penetration and Level of Implementation

Level of Implementation	Less Than Half	More than Half	All	Totals
High (fidelity)	3	2	2	7
Moderate (adaptation or partial)	7	14	2	23
Low (selective use as supplement)	5	5	3	13
Totals	15	21	7	43

Note: Fisher's Exact Test p. = 0.7506. Not significant.

In Table 35, we display data on the relationship between the level of implementation and the proportion of a school's faculty who participated in IN-STEP in the first year. We refer to this as the degree of penetration. The hypothesis is that implementation is likely to be higher if the teacher has colleagues who are working to make the same or similar changes in their practice. Here again, we find no relationship at this point. This is surprising, but it might be because in the instances where there are multiple teachers from the same school participating in IN-STEP, they are teaching different modules at different grade levels and therefore are not well positioned to help one another.

Table 36 examines yet another hypothesis drawn from research in schools in western nations—that the level of teacher collaboration in a school or department is positively related to the level of implementation of instructional reforms. But as we saw earlier, the level of collaboration in the schools in Phang-nga is quite low, so teachers may be unaccustomed to this kind of support and, therefore, collaboration may have little bearing on their decisions to use or not use new instructional materials. However, the data do show a weak positive relationship between reported levels of collaboration and the level of implementation.

Table 36. Level of School Collaboration and Level of Implementation (N = 42)

Level of Implementation	None or Weak	Moderate	High	Totals
High (fidelity)	3	2	2	7
Moderate (adaptation or partial)	18	3	1	22
Low (selective use as supplement)	6	5	2	13
Totals	27	10	5	42

Note: Fisher's Exact Test p. = 0.0865. Not significant.

Summary. Overall, the rate and level of implementation of the first units were about what one would have expected, perhaps better than might have been expected given the problems with delivering materials, the time of the year, and the degree of classroom change being asked of teachers. Nevertheless, there was a lot of adaptation and a number of cases of weak implementation and use of the materials as supplements rather than the primary instructional medium. All of this suggests that clarifying expectations for participants, giving more attention to anticipated problems at the workshops, providing more follow-up support (perhaps through regional teacher meetings), and briefing principals are needed to improve the level of implementation in the second round.

VIII. The Mentors

The IN-STEP mentors are accomplished teachers who possess knowledge about content, pedagogy, assessment, standards, and curriculum and have volunteered to assist teachers with the implementation of the IN-STEP units and improving their instructional skills. They have been trained in classroom observation and other skills needed to assist teachers. They seek to build trusting relationships with teachers so that they are welcome in classrooms and can provide effective feedback and engage in reflective conversations about teaching practices. Through such constructive meetings, mentors are able to assist teachers with planning, teaching, assessing, and reteaching to improve student performance. They collect information about students, teachers, classrooms, and schools and keep it confidential. They share the information only with the IN-STEP research team.

The Recruitment of the Mentors. Mentors were recruited from the IN-STEP instructional teams on a voluntary basis. They were enthusiastic in taking on this mentorship role, motivated as they were by the opportunity to develop their professional skills and to support their teacher peers. In the first year, they attended training in June, 2007, and October, 2007. The first session focused on developing observation and meeting facilitation skills whereas the second training focused on developing questioning and feedback delivery skills

Table 37. Perceptions of the Quality of the Mentor Training

Overall Mentor Workshop Quality				
Training Session	**Module**			
	EIS	**EMM**	**L**	**Overall**
Session 1 (4 pt scale)	-	-	-	3.68
Session 2 (5 pt scale)	4.42	4.64	4.92	4.6

Source: Session 1 Mentor Questionnaire June, 2007, N = 17;
Session 2 Mentor Questionnaire October, 2007, N = 14.

Table 37 shows that the mentors rated the first training session highly, with an average rating of 3.68, based on a four-point scale. In the second training, a five-point scale was used and the average rating was about 4.6.

Activities of Mentors. Each mentor was assigned to work with two to three teachers whose schools were in close proximity to the mentor's location. They were asked to organize a meeting with the teachers assigned to them to discuss the use of IN-STEP and related pedagogical issues, and then to meet with each teacher individually. Thirteen of 14 mentors organized the two meetings.

Table 38. Conducting Teacher Meetings

Did mentor meet teacher?	Module			Total
	EIS	EMM	L	
Yes	4	5	4	13
No	1	0	0	1
Total	5	5	4	14

Source: Mentor Questionnaire October, 2007, N = 14 (of 17).

Table 39. Attendance at Teacher Meetings

Did all teachers attend the meeting?	Module			Total
	EIS	EMM	L	
Yes	3	5	4	12
No	2	0	0	2
Total	5	5	4	14

Source: Mentor Questionnaire October, 2007, N = 14 (of 17).

Table 40. Teachers' Perception of Mentor Support (Four-Point Rubric)

Scale	Level of Support	Quality of Interaction	Level of Teacher Receptivity
EIS	2.53	2.69	3.76
L	3.00	3.06	4.00
EMM	2.93	2.73	3.60

Source: Teacher Interviews, October, 2007.

The data presented in Table 40 show that teacher receptivity to the mentors is uniformly high among the three groups of teachers, but in spite of that, the perceived quality of interactions with the mentors and the level of support provided were not regarded as highly by the teachers. The teachers using the EIS module were especially critical, rating the level of support and the quality of interaction much lower than teachers using the other two modules. These data are in agreement with those from Table 38 showing that some mentors did not organize the suggested teacher meetings. These data imply that there should be more interaction and stronger support mechanisms between mentors and mentees. The IN-STEP team should explore how mentors can provide better support and what additional training is needed for them to carry out the mentorship task more effectively.

Table 41. Benefits of Mentoring to Teachers

	Module			
Improvement	**EIS**	**EMM**	**L**	**Total**
Teachers' confidence in science	1	3	0	3
Teaching techniques on inquiry	2	2	3	7
Confidence in using materials	0	3	2	5
Classroom management	1	2	1	4
No response	1	0	1	2
Total	5	10	7	22

Source: Mentor Questionnaire October, 2007, N = 14 (of 17), Double Count.

Based on 14 of 17 mentors, Table 41 shows that mentors believe that they can help teachers gain confidence in their knowledge of science, develop their skills at using inquiry, acquire confidence in using the material, and improve classroom management. It is noteworthy that they reported that teachers in EIS and Light did not improve much in their content knowledge. In addition, teachers in Earth in Space were perceived as not improving their confidence in using material. These teachers were less likely to attend the teacher meetings organized by the mentors. It will be interesting to compare the similarities and differences of the perceived benefits of the mentorship to teachers against teachers' reports of what they gained from their mentors. It will be useful to explore whether the problems in the relationships come from the mentors' side or the teachers', whether mentors need additional training in those areas, or whether teachers need training in how to work with a mentor.

Table 42. Benefits to the Mentors (Number of Mentions)

	Module			
Improvement	**EIS**	**EMM**	**L**	**Total**
Knowledge	0	0	1	1
Teaching technique	1	3	0	4
Mentor technique	1	1	1	3
Networking	3	3	1	7
Experience	0	2	0	2
Questioning skills	1	3	1	5
Using materials	1	0	0	1
No response	1	0	2	3
Total	8	12	6	26

Source: Mentor Questionnaire October, 2007, N = 14 (of 17), Double Count.

The data in Table 42 show a mixed pattern of perceived benefits to the mentors themselves. It is noteworthy that the mentors do not believe that they have gained in content knowledge. However, five of 14 mentors reported that they improved their questioning skills, an area in which they received explicit training in October, 2007. The team needs to consider what knowledge and skills are needed to improve the efficacy of the mentoring process and then develop a structured training plan for mentors over the next two years.

Summary. The initial feedback about the mentoring process shows that it has worked rather well. The mentors have carried out the responsibilities assigned to them and report that teachers are receptive to their support. The feedback from the teachers is more mixed; they do not all perceive the mentoring to be highly useful. However, the majority are positive and the process can be expected to improve.

IX. The Impact of IN-STEP to Date

What has been the impact of IN-STEP to date? At the national level, there is continued interest in IN-STEP. In fact, if imitation is the highest form of compliment, then IN-STEP was complimented when the IPST adopted some key aspects of the model for the design of its new science initiative in 10 other provinces. Like IN-STEP, this initiative is providing intensive, curriculum-based professional development to teachers, but it does not provide them with instructional materials and it relies on university faculty to provide the training. At the provincial level, the Phang-nga ESAO is highly supportive of IN-STEP and has opened a resource center to replenish the modules.

At the school level, it is too soon to tell. Two leading indicators might be how many of the current participants return for the second round of workshops and how many teachers volunteer to participate in the next cohort from the schools that have already sent teachers to the workshops. If almost all of Cohort 1 participate in the second round of workshops, this would be a positive indicator about the likelihood of continued use of the modules, and if many additional teachers volunteer from the schools now participating, this could be interpreted as a positive sign that IN-STEP is attracting the attention of teachers and taking root in these schools. Conversely, if few volunteer, this would be a discouraging sign about future implementation because it would indicate that those teachers who have been exposed to IN-STEP are not being excited by it, or are put off for some reason.

At the classroom level, it is also simply too soon to say. We know that almost all of the teachers used the new curriculum materials, but we also know that only seven of 43 used them exactly as they were designed. And we know there are powerful forces—negative teachers and principals, pressure to prepare students for exams, and new admissions tests in some of the province's high schools—that could undermine the use of the IN-STEP curriculum materials. In the future we will seek better measures of classroom use of the modules and also seek to link student mastery of the concepts in the modules to the level of use of the IN-STEP materials.

So IN-STEP is already having some impact, but it is too soon to assess its impacts on teaching practice and student learning, and these are the critical outcomes.

One major challenge in assessing impact on student learning is obtaining standard measures of student performance from the schools. The new National Assessment samples schools and therefore is probably not useful for evaluation of the project. IPST has offered to create an assessment for 9th graders that is sensitive to the content of the nine IN-STEP modules, but this assessment does not yet exist and it remains to be seen if teachers and students will take it seriously. However, it may be the only way to obtain a good measure of the pilot’s impact on science learning.

X. General Findings, Challenges, and Recommendations

Here are the key findings from the evaluation of IN-STEP after two years of project development and one year of implementation:

1. Enthusiasm for the instructional reforms and for the IN-STEP approach to reform remains high among the partners, including provincial and IPST officials, principals, and teachers. People feel the strategy is thoughtful and likely to work. The teachers who have attended have for the most part attended willingly and with enthusiasm. Teachers attending the workshops report that most of their colleagues who have not yet attended feel positive about IN-STEP.

2. Teachers participating in IN-STEP have been recruited primarily from the larger schools in the province. Many of the larger schools sent two or more teachers. Twenty-four small schools have yet to send teachers. This has implications for future recruitment and for the provision of implementation support (see below).

3. Teachers, instructional team members, and mentors have a generally high opinion of the training they have received to date and feel well-prepared for the work they are expected to do. Teachers are the most critical group, but the most common criticism is that they need more of the kind of training they are receiving.

4. The level of use of the IN-STEP instructional materials is relatively high—36 out of 43 teachers actually used all or most of the curriculum modules they received. However, they made many adaptations and implementation was uneven, in part due to the late arrival of the materials (near the end of the semester) and in part due to reluctance on the part of teachers to totally give up the familiar old curriculum.

5. The only information we have about the response of students comes from their teachers. We might expect that data to be biased to the positive side since teachers would likely feel that negative responses would reflect on their teaching and would reflect poorly on their students. Keeping that potential bias in mind, the findings are mixed. About 80% of the teachers report that their students are moderately to highly engaged by the materials, a less enthusiastic response than might have been expected. But inquiry is new to the

students as well as the teachers and demands more of them, so perhaps this is a predictable response. The same percent of teachers report that their students are able to master the material. This leaves a significant group, about 20% of the teachers, who are reporting problems with engagement and mastery. This group disproportionately comes from the Light unit. These teachers need to be targeted for more support from the mentors in the next round, and the Light instructional team needs to explore the nature of these problems and address them in the next workshop.

6. The support structures put in place by IN-STEP are functioning. Almost all of the teachers were visited by a mentor but only two-thirds of those visited felt this support was useful. While it is too soon to tell if the planned supports are adequate, they might not be robust enough to deal with the teachers from the many small schools in the province that have yet to send teachers to participate.

7. Teachers report very low levels of collaboration in their schools. When asked who they turn to for support in science, half say they rely on themselves. There is little evidence of functioning professional communities in science in the schools or across schools in the province. The good news is that IN-STEP has an opportunity to improve conditions for science teaching. The bad news is that it seems unlikely that peer support will be robust enough in many schools to ensure implementation. Hence, we have concluded that in addition to on-site mentoring, periodic network meetings should be organized in several regions of the province to provide implementation assistance and model collegial support.

8. Almost all of the volunteer mentors made efforts to provide support to the teachers assigned to them. And the teachers indicated that they wanted support form the mentors. However, the teachers gave mixed grades to the support they received from the mentors.

Challenges and Recommendations. Seven major challenges face the IN-STEP team in the next year: Getting teachers to implement the modules as they were designed at least for their first use of the materials; building more collaborative cultures among teachers in the province; targeting recruitment this year and preparing to support teachers working in isolation in small schools by strengthening the overall quality and quantity of implementation supports; helping teachers get students more engaged in inquiry; expanding the instructional teams and developing local team leadership; managing the resource center and effectively replenishing and redistributing the modules; and collecting data on student performance in science.

Implementing with Fidelity. Only seven of the 43 teachers implemented the first modules exactly as they were designed. And at least 13 teachers did not implement the full module during 2007, using only selected materials to supplement their old text. This suggests three possible problems: (1) The modules make new demands on teachers in terms of time, methods, or equipment that cannot be met; (2) the preparation and support provided for the teachers are not adequate to the demands of implementation; or (3) the expectations that the units be fully implemented have not been made clear enough. The available data do not provide a clear answer and the best guess is that all three of these problems are affecting implementation to some degree. The evaluation team will probe the causes of incomplete or partial implementation in the coming months. In the meantime, it is recommended that expectations for full and faithful implementation be made clear to both principals and participating teachers. This means that IN-STEP teams will need to make sure that the principals understand that the recruited teachers must be scheduled to teach a regular class that uses the module they are being trained to teach. Second, it is recommended that teachers who did not implement the module in 2007 not be invited to continue in IN-STEP unless they commit to implementing both the first and second modules in 2008. Third, it is recommended that the instructional teams stress fidelity on first use of the module and that they include a trouble-shooting session in the workshop to address common problems that may arise.

Building More Collaborative Professional Cultures. The data show that collaboration is not the norm in the schools. Moreover, the current implementation support from mentors is being given mixed reviews from the teachers. It seems unrealistic to develop collaborative school cultures in the short run as the combination of professional norms, experience, and organizational conditions mitigates against it. However, the support of peers and peer pressure are important factors in implementing new instructional approaches and changing practice. How then to resolve this dilemma? We recommend that IN-STEP provide teachers with experience in collaboration by conducting periodic teacher meetings led by mentors and IN-STEP staff. These might be organized for three or four clusters of schools and occur three times a year. The meetings could be forums for teachers to share their experiences with the new content and instructional materials, solve common problems, introduce new ideas such as formative assessment, or strengthen critical skills such as questioning strategies.

Focusing Recruitment Efforts. Given the conditions in the schools, the need to strengthen support structures, and the increased engagement of teachers from smaller schools who work in isolation and who were not early volunteers for the program, the IN-STEP team needs to think carefully about its recruitment and roll-out strategies. One strategy would be to focus on scaling up participation of faculty in the schools that are already involved in the project as much as possible, perhaps limiting the number of new sites that are brought into the project each year. The advantages of this strategy are twofold: First, it might increase both peer pressure and peer support in the schools, producing higher rates of use of the curriculum; second, it makes the management of the IN-STEP support system easier in that there will be multiple teachers in each school. The alternative strategy would be to intentionally recruit volunteers from the 31 schools that have not yet sent teachers to IN-STEP training, but to do it by clusters in order to build a critical mass of teachers engaged in each of three regions. The IN-STEP support system then might focus on teacher meetings in the clusters rather than school-level support. We favor the former strategy because we believe, from past experience and research evidence, that it is likely to have more positive effects on the level of use of the materials and changes in teacher practice. The two strategies might be used in sequence, focusing on rollout within schools in 2008 and a cluster approach to recruitment in 2009.

Engaging Students in Inquiry. Inquiry is not only new for teachers, it is new for students as well. It makes new demands on their work effort and requires different dispositions and skills than those required by the more passive, teacher-centered instruction they are accustomed to. Thai students are not used to learning through questioning, critical thinking, analyzing, presenting and providing conclusions on their own. This is not an easy problem to solve but it cannot be ignored as poor student response will discourage teachers and in the end defeat the purpose of the reforms. Therefore, we recommend that IN-STEP consider developing some model lessons that help introduce students to inquiry and develop the skills they need to engage in this kind of learning. The successful British program, Thinking Science, might be used as a source of lessons that could be adapted for use in Thai classrooms.

Expanding the Instructional Team Capacity. As IN-STEP expands to offer training on nine modules and serve over 130 lower secondary science teachers in Phang-nga, the demand for instructional team members will increase. In the third year of the project, 36 to 45 educators must be recruited to serve on the instructional teams. For the most part, these new members are likely to be recruited from the ranks of the participating teachers, but it would be useful in several respects to recruit team members from the local universities. The combination of university faculty and accomplished teachers would provide expertise in both content and pedagogy. It is essential that all members of the instructional teams be familiar with the content of the modules and have some experience using the modules.

Many instructional team members—17 in 2007—also serve as mentors, providing on-site support to teachers. They are donating their time to assist colleagues with the improvement of instruction. Again, as the project expands, more mentors will be needed and the demands on mentors will increase as IN-STEP begins to recruit in smaller schools where science teachers may work alone and to recruit teachers who are likely to be reluctant participants.

Finally, the plan is to hand off the leadership of instructional teams to Thai science educators. One of the six instructional teams offering workshops in April, 2008, will be led by a Thai educator. This process will need to be accelerated to provide Thais with experience leading teams for all nine modules.

Creating an Effective Resource Center. The Kenan Institute Asia and the ESAO have established a resource center to replenish the modules to ensure their continued use. K.I.Asia has provided a staff person to do this work and the ESAO has provided the building (and renovated it). This process will become more important, and more demanding, as the number of teachers using the modules and the number of modules in use both increase. To protect the investment in the modules and ensure their effective use, this operation will have to be well-managed. It will be important to examine how it works in this first round, and then make projections for what will be needed to handle the increased workload in 2009, 2010, and beyond.

Developing Student Performance Data. Finally, in order to demonstrate the impact of the new instructional materials and pedagogy on student learning, measures are needed that are sensitive both to the content of the modules and to students' understanding and capacity to use inquiry. The current assessments do not meet this need. IPST has offered to develop a science assessment for Phang-nga that focuses on the content of the IN-STEP units and assesses the use of inquiry. Development of this assessment should be a priority for 2008 as the last opportunity to capture "baseline" data. So far, students have been exposed to only one module, but in October, 2008, they will experience a second one and we will no longer be able to capture the baseline data needed to measure the impact of IN-STEP on student learning.

Appendix A. The Context for Reform of Science Education in Thailand

by Kessara Amornvuthivorn

Thailand faces stiff economic competition from its neighbors in Southeast Asia. While Thailand's economic growth was hailed as an Asian Miracle in the early 1990s, it has slowed in recent years in the face of increasing economic competition from rapidly growing countries in the region like China and Vietnam. Several factors are contributing to Thailand's loss of competitiveness relative to neighboring countries in the region. First, Thailand's scientific and technological (S&T) capabilities have been weakening since 1998. It ranked 32nd in the world in 1997 in both technological and scientific infrastructures but dropped to 48th and 53rd place respectively by 2006.

Table 1. Ranking of Scientific and Technological Capability, Thailand

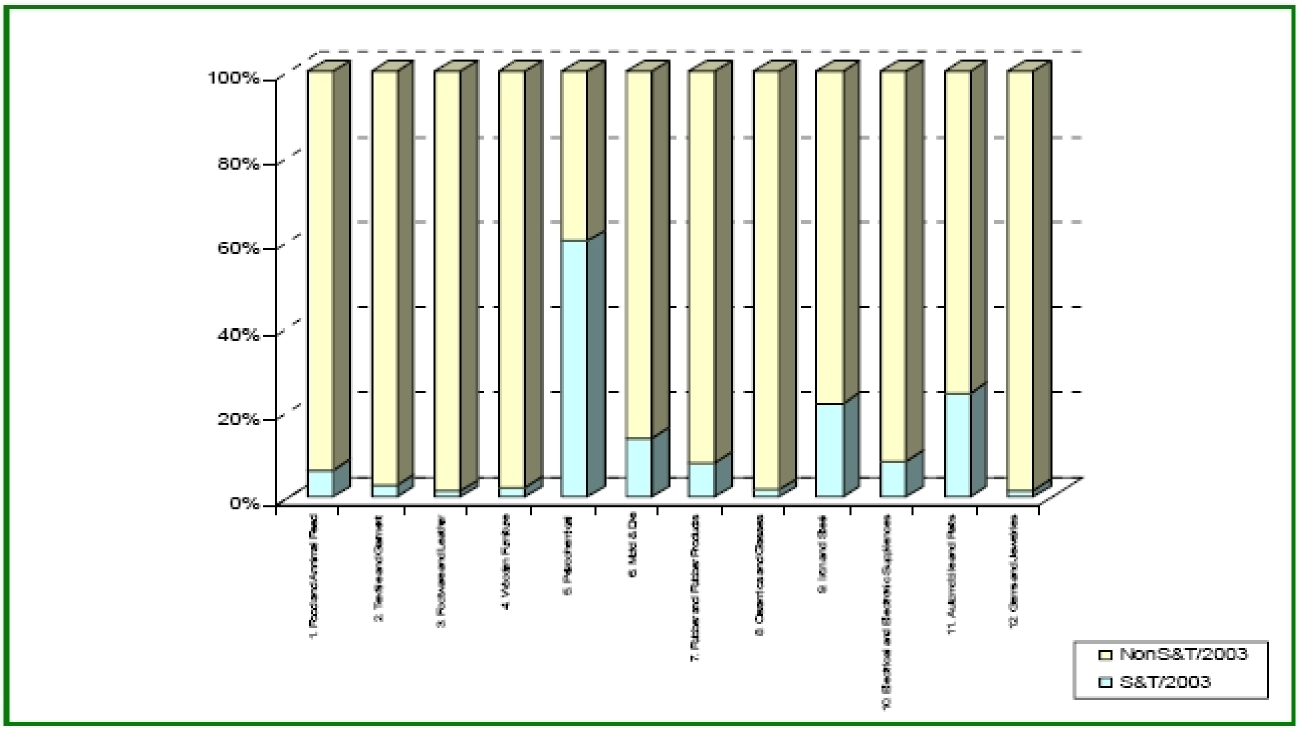
Infrastructure	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Technological Infrastructure	32	43	47	47	48	43	20	45	45	48
Scientific Infrastructure	32	43	48	47	49	46	26	55	56	53
Numbers of Countries Assessed	47	47	47	47	49	49	30	60	60	61

Source: IMD, various years.

One factor contributing to the decline in Thailand's standing in scientific and technological capabilities is the low percentage of jobs in its major industries requiring such skills. From Figure 1, it is apparent that more than 90% of the workforce in Thailand's main industries are employed in jobs that do not require S&T skills. Only in the petrochemical industry is a majority of the workers—nearly 60%—required to have S&T skills. In fact, the International Institute for Management Development (IMD) ranked Thailand's labor market 37th out of 61 countries in terms of the availability of skilled labor (2006).

Figure 1 shows that most sectors in Thailand's economy do not require large numbers of workers with technical and scientific skills. But, the educational level and skills of the available workforce in Thailand may contribute to this pattern of development since industries requiring workers with technical and scientific skills are more likely to be attracted to nations whose workers have these skills. The World Bank's Private Investment Climate Survey of Thailand found that the skill deficiencies of the available workforce were the number-one concern of companies operating in Thailand (2004).

Figure 1. Percent of S&T and Non S&T Workforce Classified by Industry



Source: Thailand Research and Development Institute (2004).

While Thailand has received deserved praise for its successful efforts to expand access to education and raise the level of educational attainment as measured by years of schooling, its schools are not yet providing the quality of education needed to support sustained economic growth. If we examine how well Thai students have performed on international mathematics and science tests, we can see evidence of the quality problem. Results from the TIMSS and PISA assessments suggest that Thai secondary education students perform well below the average of students in other participating nations and, most importantly, lag behind students in other East Asian countries.

Table 2. Trends in International Mathematics and Science Performance

	1995		1999	
Country	**Math**	**Science**	**Math**	**Science**
Singapore	608.59	580.35	604.39	567.89
South Korea	580.72	545.78	587.15	548.64
Taiwan			585.12	569.08
Hong Kong	568.89	509.73	582.06	529.55
Japan	581.07	554.47	578.60	549.65
Malaysia			519.26	492.43
Thailand	516.22	510.04	467.38	482.31
Indonesia			403.07	435.37
Philippines			344.91	345.23

Source: Third International Mathematic and Science Study (TIMSS), as cited in the World Bank (2005).

In addition, results of the 2006 Program for International Student Assessment (PISA) science assessment indicate that 15-year-old Thai students score well below their peers in other Asian countries in mathematics and science except for those in Indonesia. As Table 3 displays, Thai students on average scored more than 100 points lower in mathematics and science than students in four advanced Asian economies. As 74.7 points on the PISA scale represents one proficiency level (there are six levels on the assessment), this means Thai students are on average scoring more than one level lower than students in these other Asian nations.

Table 3. Program for International Student Assessment (PISA) Science Scores for Asian Nations, 2006

Country	Mathematics	Reading	Science
South Korea	547	522	556
Taiwan	549	532	496
Hong Kong	547	542	536
Japan	523	531	498
Australia	520	527	513
Thailand	417	421	417
Indonesia	391	393	393
OECD Average	498	500	492

Source: OECD, PISA 2006 Science Competencies for Tomorrow's World.

Even more worrisome, few 15-year-old Thai students scored at the highest levels on the mathematics and science assessments. Table 4 compares the percent of Thai students scoring at the two highest levels on the seven-point scale used by PISA with results from other Asian nations. These data reveal there are many fewer highly qualified students in the pipeline in Thailand than in the school systems of some of the nation’s economic competitors.

Table 4. PISA Percent of Students Scoring in Categories 5 and 6 in Science: All Participating Asian Nations

Korea	9.2	1.1	10.3
Taiwan	12.9	1.7	14.6
Hong Kong	13.9	2.1	16.0
Japan	12.4	2.6	15.0
Australia	11.8	2.8	14.6
Thailand	0.4	0.0	0.4
Indonesia	0.0	0.0	0.0
OECD Average	7.7	1.3	9.0

Source: OECD, PISA 2006 Science Competencies for Tomorrow's World.

The data from TIMSS and PISA reveal a large achievement gap between Thailand and its economic competitors in the region. These indicators make it clear that it is critical to the nation's economic development that action be taken to improve the quality of education in science and mathematics.

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Appendix B. IN-STEP Curriculum Modules

Each module is organized around a major topic in science and contains 4-8 weeks of lessons that are designed to build student understanding and include investigations that provide opportunities for students to do science. The modules contain all of the equipment and materials that are needed to teach the lessons and conduct the investigations. Developed in the United States, the modules have been translated and adapted for use in Thailand and serve as the foundation of the IN-STEP science education initiative.

2007

Light

Earth in Space

Energy, Machine, and Motion I

2008

Properties of Matter

The Human Body System

Energy, Machine, and Motion II

2009

To be determined

Appendix C: Map of Phang-nga Showing the Location of Schools Within the Province.