CYCLE-4 FINAL REPORT

1. **Cover Page**

Name of the project: **Making Science Accessible to 4-8 Grade Students through Inquiry and Literacy**	
Project Director	Dr. Gouranga Saha, Associate Professor of Science & Technology Education
	Contact Address: MLK 404, Department of Education, Lincoln University of Missouri, 820 Chestnut Street, Jefferson City, MO 65102, Telephone Number: **573-681-5215;** sahag@lincolnu.edu
Co-Director	Dr. Dennis Nickelson, The then Head of the Science Department, Jefferson City High School (Currently Assistant Professor of Mathematics, William Wood University, Fulton).
	Contact Address: 3204 Schott Road, Jefferson City, MO 65101, Phone: 573-680-1319 (Cell) Dennis.Nickelson@Williamwood.edu
Co-Director	Dr. William C Kyle, Desmond Lee Family Professor of Science Education
	Contact Address: College of Education, University of Missouri, St. Louis, 8001 Natural Bridge Road, St. Louis, MO 63121 – 4499; Phone: 314-516-5375 Bill_kyle@umsle.edu
Statutory partners	Department of Agriculture and Natural Science, Lincoln University, Department of Education, Lincoln University, Jennings School District, Normandy School District and St. Louis Public Schools.

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2. **Project Abstract/Summary**

Project Title: Making Science Accessible to 4-8 Grade Students through Inquiry and Literacy

In partnership with its Division of Education and Department of Agriculture & Natural Sciences, Normandy and Wellstone School Districts and St. Louis Public Schools (Ashland Elem, Blewett Middle, Gateway Middle, Mel Carnahan Middle and Webster Middle Schools in particular), Lincoln University led the cycle 4 project, "Making Science Accessible to Students through Inquiry and Literacy." Jefferson City High School represented the K-12 classrooms and University of Missouri at St. Louis (UMSL) represented as an additional higher education partner in this project. Four higher education faculties including the director worked on this grant project. Twenty Six elementary and middle school science teachers participated in this professional development (PD) project. The target content area was 'Force, Motion and Mechanical Energy.' The project was organized into THREE Levels. **Level -I** was the Summer Workshop and **Level-II** was the classroom visits and the third (**Level III**) was the Saturday Follow-up sessions. Level-I started in summer 2006 and continued for 12 days, 6 hours a day from July 5th to July 20th, 2006 (M-F). Two initial days of this workshop were dedicated to pedagogical strategies in teaching and practicing inquiry as a process to understand what inquiry means to teaching and learning science following best practices of science instruction strategies, modeling of a 5E inquiry activity on Force & Motion, and discussing on assessment and reflective practices to monitor science learning processes. In the afternoon of day 2 the participant teachers experienced how to integrate literacy with science content. From day 3rd to 12th, (9 days) the participant teachers experienced hands on inquiry activities to gain knowledge on DESE content GLE Standard 2: Properties and Principles of Force and Motion (Show-Me Science Curricular Strand – IV: Force, Motion and Mechanical Energy) within the same 5E inquiry format. The entire target content learning sessions were sequentially divided into concepts under the appropriate big idea of the strand for the convenience of attaining 'structural knowledge' (Jonassen, et. al., 1993) to understand how concepts within a big picture are interrelated. Each day had two sessions – morning for hands-on inquiry activity & afternoon for reflection and consensus building via whiteboard and concept map techniques. In the second week of the summer workshop, the participant teachers were also guided to write and assess 5E Science Unit & Lesson Plans on the target content using the DESE GLEs aligned particularly with MAP assessment format. They then used these lesson plans to practice teach the summer school children of the host school in order to conduct the 'lesson study research' which were video-taped for reflection purpose.

During the support-cum-implementation (Level-II) each participant teacher's classroom was visited twice to observe, sometimes co-teach (particularly questioning strategies), mentor and reflect on their teaching strategies. There were NINE Saturday sessions (Level –III), 4 hours each for when each lesson study group presented their lessons and their video-taped summer teaching was evaluated and reflected upon, new ideas of teaching the lesson were suggested and content knowledge was reinforced and also discussed the classroom observations recorded on the checklist used for the purpose.

Participant teachers took content and literacy pre-tests at the beginning and a post-test (1st) at the end of the summer workshop (Level-I) and also a final last post-test

(2nd) at end of the Level-III. There was a mean difference between the pre- and 1st and 2nd post-tests which were statistically significant. We also administered a pre- and post survey on the knowledge and use of inquiry as a science instructional strategy to the teacher participants at the beginning of level-I and at the end of Level-II & III that showed significant positive changes of the participant teachers' knowledge and use of inquiry as a science instructional strategy. A satisfaction survey at the end of Phase-I and Level III also indicated increased satisfaction of the participant teachers for this PD. A positive trend of gaining more confidence and aptitude to teaching inquiry science was noticed among those teachers who participated in our projects more than once. Participant teachers administered pre- and post-tests on the target content to their students. Post-tests indicate an increased student achievement on the target content.

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4. **List of school districts and the number of participants from each (High-Need School Districts Highlighted)**

School District	Number of Participants	Average Contact Hrs for the Participants*
Normandy School District	**4**	**99.47 contact hours**
St. Louis Public Schools (SLPS)	**21**	
Warren Co R-II School District	**1**	

*Time Period for Contact Hours: July 2006 to May 2007 (Total Contact Hrs = 108 (72 hours during Summer 2006 & 36 hours for 9 Saturday Follow-up)

5. **Description of project activities completed by participants**

There were 26 teacher participants (Appendix I) in LU project. The project was guided by five objectives and was grounded in situated learning model" [1] of professional development (SL-PD) focusing on actual teacher work. Accordingly activities of this project were designed following an effective teaching (best practices) or pedagogy that includes deep inquiry, cooperative learning, construction of meaning of content through consensus building [supported by technology], 'lesson study' (Appendix II), classroom workshop and mentoring, and reflective assessment [4]. The project was composed of three vital elements – (1) summer workshop including active inquiry activities and 'lesson study' for intervention, (2) classroom coaching and mentoring visits during academic semesters to help implement the project prompted model in participant teachers' classes effectively, and (3) Saturday Sessions for reflections, further mentoring and peer evaluations of each other's 'lesson study' and classroom teaching.

The summer institute was held from July 5-20, 2006 (Monday-Thursday) for 6 hours/day. The institute included four main components:

1. Drs. Saha and Kyle provided a few hours of pedagogical instruction on what inquiry-based teaching is and how to use a 5E learning cycle approach to develop inquiry-based science activities.
2. Drs. Nickelson and Borgwald worked with the teachers through learning cycles on Forces and Motion using a 5E model of inquiry.
3. Teachers participated in a 1-week intensive lesson study activity where they planned, taught, revised, and re-taught a learning cycle lesson to summer school students.
4. Dr. Nancy Gammon, a literacy professor from Lincoln University, introduced interdisciplinary connections between science and literacy, specifically how to use certain literacy strategies (e.g., Venn diagrams) to support students' science learning.
5. The summer workshop for the project continued for 12 days, 6 hours a day from July 5th to July 21st, 2006 (M-F) (Appendix III). On July 5th, teacher participants first took the content pre-test on the Force and Motion concepts (Appendix IV). Then they took "Inquiry attitude and frequency" (Appendix V) survey consisting of 10 items. Finally they took a pretest on the technique of integration of Literacy in to science

(Appendix VI). At the end of the pretests on July 5th and then on 6th teacher participants were exposed to a workshop (Appendix VII) on inquiry - what inquiry means to teaching and learning science through 5E learning cycle, video on inquiry process, inquiry classroom environment and inquiry activities related to scientifically-based science knowledge construction process supported by technology. Through a PowerPoint discursive presentation the teachers were then guided to know & understand the various categories of inquiry (Appendix VII), what is inquiry and what is not, when each category is cognitively appropriate for a grade level to use and practice and how to progress towards open-ended inquiry to learn & do science. We also treated the concept and strategies of promoting a critical thinking process, and adaptive teaching for diverse learners. Teachers were then led to explore the inquiry standards (Appendix VII) to understand what the teachers need to do to institute inquiry in his/her instruction and what indicators tell him/her that students are doing inquiry. In short, the main goals of these workshops and the PPT presentation were for the participant teachers to conceptualize, "What inquiry means to teaching and learning science." At this point we introduced our own S_bSL (Saha, 2002) model of inquiry teaching strategy. In short, the attributes of this model are: (1) engage learners in a problem or question, (2) develop fair tests and collect data, (3) make sense of data, (4) communicate findings and negotiate a consensus, and (5) Provide resources for the learners to become aware of the contemporary scientific views about the target concepts.

In particular, this workshop looked at what is needed for building the foundation conducive to promote inquiry and preparing their students for inquiry investigation.

After the teachers became acquainted with the state and national characterizations of the inquiry science learning process, they were familiarized with 5E science inquiry instruction format. At this junction, we provided a sample K (what we know?), W (what we wanted to know?), L (what did we learn?) and Q (what further questions do we have?) chart as an interface with the 5E format to promote student questioning (Appendix VIII). Finally they learned the techniques of writing and maintaining daily journal of their experiences during the summer workshop.

After being introduced to the alignment of SLPS District curriculum & GLEs with the project's pedagogy, the participants were presented with science content DESE GLE Standard 2: Properties and Principles of Force and Motion (Show-Me Science Curricular Strand – IV: Force, Motion and Mechanical Energy). To gain this target content knowledge, participants conducted inquiry activities within the 5E inquiry format for the rest of the summer from July afternoon of July 6th to 20th (For July 10th to 14th in the afternoon). For the purpose, participant teachers were grouped into two - elementary and middle school groups. Each of the above days from 8:30 to 12:00 the teachers were led through activities on all the concepts under big idea 1 and 2 (time didn't permit to cover more concepts as intended) of strand 2**:** *Properties and Principles of Force and Motion* for grades 4-8 (Appendix IX). Interspersed with the science content lessons were standard-analysis activities, technology lessons, and comparing the science content in the institute with the content in the SLPS textbooks. The professional development (PD) project selected the Prentice Hall Science Explorer textbook series as the institute curriculum because one of our partner school district, St. Louis Public Schools (SLPS), had recently adopted it district-wide and the teachers had not received much professional development on using the textbook. Over the three weeks of the summer institute our team focused much of the instruction on the grade 7

text as a basis for developing the three learning cycles on *Force and Motion*. We modified the units in the textbook to fit with our project goals by: a) adding literacy connections, and b) describing how to best approach the topic of study across the various grade levels (e.g., how to modify topics appropriate for grades 4, 5 and 6). The team provided the teachers with copies of the Missouri State Grade Level Expectations (GLEs) and referred to them during discussions of curriculum alignment throughout the institute. (Each teacher received a set of the same classroom equipment that was used during the summer for the science instruction in his/her own class).

Reflective session followed the activities every day in the afternoon from 12:30 to 3:00 PM when teams were brought together to defend or change their meanings via peer discussions and negotiations following a research based process of science knowledge making process (http://www2.physics.umd.edu/~redish/Talks/Revitalize/sld006.htm) to discuss and reflect on the inquiry activities to make meaning of the data in constructing knowledge via consensus knowledge building using the white board as a tool. During this meaning making process, the team focused its questions on probing the teachers to think more deeply about their responses or clarify items that they wrote on their white boards (e.g., define certain terms they used in their own words or explain their responses in terms of the forces acting on one card and not both cards). This part used to culminate into organization of knowledge in the form of a concept map. Dr. Nancy Gammon facilitated the participants with the techniques how to integrate literacy into the inquiry science teaching by 'extracting meaning from science texts' in particular during this part of the summer institute. All teachers individually kept notebooks of their work and always referred back to them repeatedly during this workshop.

After the teachers made their claim, through group consensus, they were provided with textbooks and taken to a selected Internet sites for web-based visualization (Appendix X) and individualized practice activities of the targeted concepts. These exercises helped the teachers to become aware of the contemporary scientific views about those target concepts. This awareness provided them the opportunity to compare the status of their constructed knowledge to revise/alter or modify their own knowledge claim(s) if needed, examining their data and figuring out what variable/s they needed to look at again (if necessary) - a conceptual change process that has more power to explain phenomena in other problem-based contexts. The grant team maintained an observation checklist to assess the extent to which the participants were using 5E inquiry/ Inquiry during their activities (Appendix XI).

Lesson Study: Having the above input, the participants were engaged in the 'lesson study' during the second full week (July 10-14) of the summer institute. The teachers worked in groups of 4-5 to develop a 45 minute lesson that a couple of members of the team co-taught to a group of host school (Compton-Drew) summer school students in the morning. Because the PD project team had spent the first two days of the summer institute on the content (July 6th & 7th) topic of simple machines and had modeled this topic using a learning cycle format, most of the groups chose to develop their lessons on the topic of simple machines. The teachers were expected to develop their lessons using a learning cycle (5E) format. The PD project team videotaped each team of teachers teaching their lesson, and planned to use these tapes as an instructional resource during the continued support school year meetings (used them and had teams and peers critique each other during Saturday sessions). However, each teaching team

was responsible for recording field notes about their team members' teaching. After their lesson, they were given a short amount of time to meet to debrief about the experience and how the teachers thought the lesson impacted student learning. During this debriefing session the teaching teams were also required to rewrite/revise their lessons based on any suggestions they had discussed such as, (1) What level of inquiry the lesson was? (2) What worked well, what did not? (3) What needs to be revised for effective learning? What did the peers say about the lesson? using the peer evaluation form (Appendix XII). Other members of the teaching team then taught the revised lesson to a new class of students in the afternoon.

Finally, an overview of what we learned during the summer was made and then the implementation strategies were discussed. Handouts (Form & strategies) on maintaining instructional and reflective journals (XIII) and schedule for Saturday sessions (XIV) were provided. At the end, reminder was given for classroom visits by the team two times during the course of the academic year ~ once during Fall 2006 and once during Spring 2007. Last not the least the participants took their post survey on "Inquiry attitude and frequency", content post test on the content using the same pre-test instruments, and Literacy Integration Technique Post and Satisfaction Survey (Appendix XV) in addition to external evaluator's on-line assessments.

Classroom Coaching and Mentoring Visits

Level two of this project was the follow-up to the summer activities. This level composed of the classroom visiting, mentoring, co-teaching, and reflecting on teachers' own lesson (implementing the project prompted science instruction). The classroom visit team was led by Dr. William C. Kyle, Jr.

Teacher population and structure of visits:

The 2006 summer workshop had 26 participants. Ideally, each teacher was going to be visited two times during the course of the academic year ~ once during Fall 2007 and once during Spring 2007 ~ for the purpose of: a) observing the degree to which each teacher was successful in implementing the goals of the workshop and b) facilitating each teacher's ability to be successful in implementing the goals of the workshop. Thus, the purpose of the classroom visits was not evaluative; rather the purpose was to provide teachers with in-class support.

Between the end of the summer workshop (July 2006) and the beginning of school in August 2006, two teachers received SLPS assignments in which they were not teaching science during the Fall 2006 semester (one resumed in Spring 2007) and one non-SLPS teacher participant did not return to teaching in her district. The non-SLPS teacher dropped out of the program completely; one of the SLPS teachers remained active while the other did not continue to participate in the program; another teacher participant did not participate throughout the year. Thus, during the Fall 2006 semester there were 22 teacher participants eligible for classroom visits and during the Spring 2007 semester there were 23 teacher participants eligible for classroom visits. This should have resulted in a total of 45 classroom visits throughout the course of the academic year.

The process for signing up for classroom visits was as follows: four times during the course of the year, at Saturday workshops, a sign-up sheet was distributed in which teachers selected their preferred date and time for the visit. All teachers signed up for at least one classroom visit each semester. Eleven teachers signed up and participated in both classroom visits (although it should be noted that on both visits one teacher intentionally had guest presenters, thus the team never actually saw her teach her class!); 2 teachers accommodated three visits during the course of the year; 6 teachers completed one visit and in most cases forgot about having signed up for the second visit and while the project team made the trip to the school they were either absent, not in the school building or not able to accommodate a visit that day; and 6 teachers continually signed up for classroom visits and then would either cancel at the last moment, not be at school when we arrived, or not be teaching science at the time we arrived to the school (which would have been the time they selected). Thus, while 45 classroom visits should have been completed, a total of 34 classroom visits actually transpired. Several teachers cancelled visits during the MAP preparation or testing period of time, but did not reschedule even when requested to do so via email and / or a final sign up request during the final Saturday workshop. In most of these cases, the teachers stated they were in schools in which from March to May they had lock downs and no visitors were allowed into the schools for any purpose. These teachers claimed that the building principals would not authorize visitors of any kind (including visitors providing classroom support) due to the behavioral problems within the school and the need during the second semester to prepare students for the MAP tests. For the most part, these teachers seldom taught science during this duration of time under the auspices of preparing students for being successful on the MAP tests. Thus, we were never afforded the opportunity to visit these six teachers.

Each of the 34 classroom visits involved the following: a) extensive communication with the teacher prior to the visit establishing what the nature of the classroom observation would entail ~ often times via electronic communication in instances where we had not previously visited the teacher; b) we would observe and participate in at least one to two class periods per visit; and c) immediately following the classroom visits the teacher and we would de-brief the visit and share ideas related to the specific science content being taught, classroom instructional strategies, additional resources and / or materials to enhance instruction; access to technology enhanced media, or additional opportunities available to students in areas of interest to them. These de-briefing conversations typically were 30 to 60 minutes in duration, depending upon the teacher's schedule (We often scheduled visits so that following the two class periods the teacher either had lunch, a planning period, or it was the end of the school day, thereby enabling the opportunity for an extended conversation). Thus, each of the 31 classroom visits ranged from being a total of 2 to 3 hours in duration. In one instance Dr. Kyle also met with the teacher and building principal to discuss ways in which to introduce central tenets of this program into the school's School Improvement Plan (SIP) for 2007 – 08; We have also reviewed and offered comments on drafts of the school's forthcoming SIP.

Purpose of visits:

Classroom visits were intended to assess the degree to which teachers were able to implement inquiry-oriented science pedagogy (with a focus upon the 5 E's). There

was also a desire to ascertain each teacher's ability to teach in a manner congruent with the goals of the workshop, and reflect upon their teaching.

The classroom visits were intended to offer teachers the kind of support necessary as they engaged in implementing inquiry-based innovations in their classrooms. It was an opportunity to engage in dialogue and reflection about science pedagogy and it was also an opportunity for teachers to ask questions of concern and/or interest to them. This informal exchange of ideas was perhaps the most beneficial aspect of the teacher visitation program as we spent many hours providing teachers with insights into curricular materials, resources, web-based references and other science education resources. In addition, we provided students with information related to science-based research, careers, and opportunities. As noted, above, in the case of one school weI assisted in the development of key ideas integrated into the school's SIP.

Trends:

Each of the 19 teachers that we visited during the course of the 2006 – 07 school year made a conscientious effort to address the spirit of the science inquiry workshop. In general, they were interested in enhancing the science teaching – learning environment and reflecting upon their pedagogy. And, while there was a willingness to engage in dialogue and reflect upon the ways in which they might offer students a positive science learning experience, there was also significant hindrances in the schools in which most of the teachers teach which often made it difficult to teach inquiry-oriented science.

Having said the above, we think it is only fair to state some constraints that offered significant roadblocks to accomplishing the goals aspired by the teachers. For example:

a) In the Cycle 3 (2006) report we noted that it was apparent that the majority of teachers really struggled with conceptual understanding of the science content they were teaching to middle school students. We also noted this is a significant issue in SLPS where many teachers teaching middle school science are actually elementary certified teachers. Many of these teachers have not had extensive science coursework (beyond their own high school science) and / or experiences with science in a societal context. Thus, in most cases, teachers do not possess the conceptual understanding and / or the pedagogical skills to instruct specific science content from an inquiry perspective. That is, in order to teach from an inquiry perspective it is imperative that a teacher understands the science conceptually, as well as possesses a wealth of information with respect to the range of conceptual understandings held by learners and the metaphors, analogies, etc. to facilitate the teaching and learning process. Further, an understanding of applications of the scientific phenomenon in a societal context is helpful; in other words, even when teachers do possess textbook understandings of the science, they often do not possess contextual understandings and / or an understanding of the science as it is used or applied in society. A significant observation during the 2007 visits is that most of the teachers who are 2 plus year participants in the program are diligently striving to ensure that they are much better prepared with respect to the science content they are now teaching. Over the course of the past two years, we have observed teachers being better prepared to teach science, more knowledgeable of the science concepts, and better able to teach science from an inquiry approach. These are

all very encouraging indicators as to the effectiveness of the overall program and its impact upon teachers' classroom instruction.

b) With each summer workshop teachers receive materials and instructional resources to facilitate their implementation of the content focus of the workshop. These materials enhance their ability to both implement the goals of the program from content and pedagogical (5E's) perspective. Teachers use the materials appropriately in the instructional environment; in part, they are effective in doing so since the workshop focused on the teaching – learning processes while having the teachers experience learning as students do in the classroom, all while utilizing many of the same materials and resources. In this regard, the summer workshop is effective in enhancing teachers' conceptual understandings of scientific phenomenon and providing them with a sense of what the teaching and learning process looks like (from a modeling point of view) as they experience the 5E's as learners.

However, we also stress that the classroom visits are not constrained to be visits when teachers are teaching the science concepts that framed the summer workshops. In fact, some teachers do not teach the content of the summer workshop at all based upon the grade level they teach. Herein lies the constraint in that the vast majority of the teachers lacked the materials and resources to implement an inquiry-based science program when they try to do so when teaching other content areas. Thus, it is often difficult for them to implement the 5E's throughout their science program. In general, the minimal materials that most teachers do have access to enable them to teach in a confirmatory or verification mode rather than in an inquiry-oriented manner. Moreover, teachers have minimal access to technology enhanced classroom environments or multi-media. In essence, students have limited opportunities to experience a rich inquiry-oriented learning environment.

c) In the Cycle 3 (2006) report we noted that the majority of teachers had to contend with significant discipline and / or behavioral issues, which challenged a teacher's ability to facilitate a learning environment conducive to all learners being engaged in inquiry learning. It is interesting to note that this year's teachers did not experience the kinds of discipline / behavioral issues, thus a much greater amount of the class time was able to be devoted to the teaching and learning of science. In a few instances the teachers were observed both in the 2005-06 school year and during the 2006-07 school year. Even these teachers had fewer classroom control issues. From our perspective it appears as though the summer workshops and the focus of the program on constructive learning has also enabled some teachers to enable the focus be placed upon teaching and learning rather than discipline and behavior and as a result students have become more focused in their classes and less disruptive.

Within the context of these overall constraints, teachers were able to exhibit the following behaviors and attitudes congruent with taking the initial steps toward inquiry-based science pedagogy (5E's) ~ regardless of the content focus:

a) The teachers have continued to be successful in implementing the white board instructional strategy as an innovation; and, they have identified ways to use this innovation in a more time constructive manner as well. As a result, teachers have

become even more focused upon the conceptual issues of importance. During the second year of observing returning teachers we also observed that students were grouped more purposely, and this in fact may have resulted in fewer disciplinary concerns during the teaching and learning process. The use of white boards has facilitated classroom discussion, offered students the opportunity to engage in group presentations, and enabled teachers to monitor student /group progress. The concern we expressed in the 2006 report remains. That is, the white board strategy is seldom (if ever) used to challenge students thinking. So, while discrepant information was often presented by groups of students the power of the white board presentations was often lost in merely accepting what students presented without engaging students in debate and cross-group discussion. Thus, from the perspective of the Science Observation Checklist that we used during our summer workshop (Appendix XI), students were able to engage in the focus of the inquiry and state / record relevant observations; and they were able to engage in within group discussions based upon data they collected (and present such findings as well), but little attention was paid to having students build upon the knowledge of other groups and seldom was the focus upon the nature of science and the search for evidence. The 2007 summer workshop placed an emphasis on the nature of science and the hallmarks of science being focused upon creativity, debate and dissent. Ideally during the 2007-08 classroom visits we will see more creative use of whiteboards in the context of engaging students in debate and consensus building.

b) Teachers gained confidence as the year progressed in their ability to foster a more open classroom environment oriented toward student engagement and inquiry. Thus, especially in instances in which we have not visited teachers 4 to 6 times over the course of the past two school years, those teachers are much more comfortable and confident in using an array of inquiry-based instructional strategies. They evidence the ability to foster within group and cross group dialogue amongst students, and they are better able to seek and use materials and resources related to the science concepts they were teaching.

c) Teachers who have been in the program for 2+ years have begun to recognize that the more actively engaged students are in inquiry-based science, the fewer classroom discipline and behavioral problems they confront. We have worked with several of the teachers to construct boundaries for acceptable behavior during inquiry lessons. In part, this is necessary as students have had minimal opportunities previously to engage in inquiry, but when provided such opportunities, students became actively engaged in the learning process. Some of the teachers specifically noted that they were surprised in the change in behavior and focus upon learning amongst some of the most disruptive students; in essence, they noted that they never knew that many of these students had intellectual interests in science. Observing such behavior changes offered teachers a sense that it was well worth the effort to foster a classroom environment more conducive to inquiry, dialogue, and sharing of ideas. Until schools begin to implement school-level reforms in that regard, teachers will continually have this issue to content with as each new group of students will have to be provided with the guidelines for inquiry learning, rather than such learning being institutionalized.

The domain of inquiry in which teachers continue to have the most difficulty is fostering disciplined scientific thinking. Determining what constitutes credible evidence, constructing evidence-based explanations / interpretations, suggesting models, critiquing explanations, and recognizing and analyzing alternative models and explanations are all domains of inquiry for which teachers encounter great difficulty fostering within the context of classroom instruction. This is in part due to their limited (conceptual) scientific content understandings and in part due to limited exposure to the history and nature of science. In the Cycle 3 (2006) report we noted that if these are goals of the program (from the perspective of teachers being able to implement such attributes of science pedagogically), then we believed that a greater emphasis in future workshops will have to be oriented toward the nature of science and scientific inquiry. Teachers need to have greater access to experiencing such scientific thinking within the context of their own learning of science content. During the 2007 summer workshop a greater emphasis was placed upon these aspects of inquiry. And, these skills were integrated into the teaching and learning processes that teachers experienced. Teachers ability to translate their learning experiences into teaching experiences will become a focus of the 2007-08 classroom observations.

Summary

Of the 19 teachers who availed themselves of the classroom visit component of the program (albeit 6 only accommodated 1 visit and 1 teacher never actually taught her class as guest presenters did), the majority evidenced personal and professional growth throughout the course of the 2006 – 07 school year with respect to their understandings of science inquiry and their ability to move toward inquiry-based science pedagogy. For teachers who were either observed twice during 2006 – 07, of those for whom it was their second year of participating and classroom support, they became more comfortable with implementing inquiry-oriented instructional strategies; they realized the need to enhance their own conceptual understandings of scientific phenomenon, and they sought out ways to do so; and, they recognized that when students were provided with real opportunities to learn that as teachers they had less behavioral disruptions to contend with in class. It was evident throughout the 2006 - 07 school year classroom visits, that a majority of teachers continued to gain confidence with respect to their conceptual understandings of scientific concepts, how to acquire knowledge and information to enhance their understandings, and their understanding of how to orchestrate an inquiry classroom that was congruent with their experiences from the summer workshops. Thus, teachers have demonstrated an interest and ability to implement essential aspects of the summer workshop to enhance the quality of the science learning environment in their classrooms. The lack of materials, resources, and in general a media / technology poor teaching environment still offers challenges to teachers with respect to providing students with the kind of educational opportunities that they ought to have access to in the process of schooling. In other words, during each visit we observed how the participant teacher implemented our teaching strategies they learned during the summer, understood why they did what they did, mentored, reflected upon their own and their students actions and interactions during the teaching and learning process which helped develop the notion of *spieldrum* (room to maneuver).

Saturday Follow-up Sessions

The third level of the project was the Saturday sessions. We had a total of nine Saturday sessions from August 2006 to March 2007. Each of these Saturday sessions started from 7:45 AM and continued up to 11:30 AM as a part of the continued support to these in-service teachers to enhance inquiry science teaching practices in order to improve their students' science learning achievements. During these sessions, teachers' video-taped 'lesson study' that we made during our summer workshop, were shown to the peer teachers who evaluated these lessons based on an instrument developed by Dr. Saha (Appendix XII). Also these support sessions provided opportunities for the affected teacher to teach their peers the same lesson using the same technique that they taught in their classrooms to talk and discuss with peer teachers and instructors about successful and unsuccessful implementation of the activities and inquiry pedagogy. Another aspect of Saturday sessions was to present teachers' classroom implementation and reflections journals and other concerns that they maintained as an evaluation measures required by the project. It helped the teacher participants to experience the classroom at the elbows of other practitioners and thereby develop a sense of the inquiry practice via the eyes of one other. To reinforce the target content knowledge for the participants on some Saturday sessions we also took the opportunity to have them conduct activities on concepts additional to those covered during the summer workshop on the target content.

6. Description of any substantive modifications to the original project

Because teachers could not obtain necessary permissions from different stake holders to videotape their students while teaching, the project could not video tape and use the participants' classroom lessons. As a result instead of watching the videos, teachers shared their implementation and reflective logs with their peers who critiqued the merits and demerits of their instructional strategies and suggested ways to improve them. Grant team member/s who visited those lessons also shared his/ their observations checklist to reflect on the instruction. Since they ran out of time to accomplish it during the summer, 'lesson study' groups taught their peers during Saturday Sessions based on the modifications they made after they taught the summer classes as a part of their 'lesson study' research.

Another modification we had to make to our original project activity was to accept lesson activities on any science strand other than the target content during our classroom visits. Because between the end of the summer workshop (July 2006) and the beginning of school in August 2006, some teachers received SLPS assignments in which they were not teaching science during the 2006 – 07 school year. These teachers dropped out of the program completely. In December 2006, a teacher who was primarily a special education teacher, but who team-taught science with a regular classroom teacher, found it difficult to continue the team teaching arrangement and therefore she dropped from the program in terms of teaching science (she continued to attend the Saturday sessions). Five teachers routinely signed up for classroom visit times, but these teachers would always email a few days prior to the visit noting some kind of conflict which would prevent the visit from taking place. These same teachers were then in schools in which from March to May they had lock downs and no visitors were allowed into the schools for any purpose. These teachers claimed that the building principals would not authorize visitors of any kind (including visitors providing

classroom support) due to the behavioral problems within the school and the need during the second semester to prepare students for the MAP tests. For the most part, these teachers seldom taught science during this duration of time under the auspices of preparing students for being successful on the MAP tests. This uncertainty disrupted our classroom visit schedule and some teachers already covered the target content following their building and district's pace chart before our actual visit took place (for more specific information on this issue please refer to classroom visit part of this report).

7. **List of state and additional project objectives**

Following SIX behavioral objectives guided the cycle 4 project.

Objective 1: To improve the 4-8 grade students' achievement in the areas of *Force and Motion,*

Objective 2: To increase 4-8 grade science teacher participants' knowledge and understanding of key concepts in the areas of *Force and Motion,*

Objective 3: To improve 4-8 grade teachers' pedagogical knowledge and practices those utilize SBR findings and best practices of inquiry as an instructional approach to teaching science,

Objective 4: To enhance participating 4-8 grade science teachers' use of student assessment data to monitor the effectiveness of their instruction as reflective teachers,

Objective 5: To improve Lincoln University pre-service teachers' science preparation strategies through improvements in their science content knowledge, and

Objective 6: To improve participating 4-8 grade science teachers' knowledge and skills of science and literacy to improve their students' science reading and writing skills.

7. **Discussion on how project has met or made progress toward meeting each of the objectives.**

Objective 1: To improve the 4-8 grade students' achievement in the areas of *Force and Motion*.

Evaluation:

To assess this objective, participant teachers developed their own test items on the target content area of *Force & Motion* and administered the instrument themselves to their students before (pretest) and after (post-test) the instruction and reported the data to us. Eighteen out of 26 (8 teacher samples were lost – sample mortality) teachers reported these scores as raw scores of their students' performances (Table 1). From the descriptive statistics we conducted using SPSS-10 on each teacher's reported scores, it appears that post-test mean is higher than that of his/her pre-test score mean score (Table 1). After we further analyzed these means to find whether these means are statistically significant using paired *t*-test we found that all these means are statistically significant at P =.000 to .005 except for the teacher D[1] who is

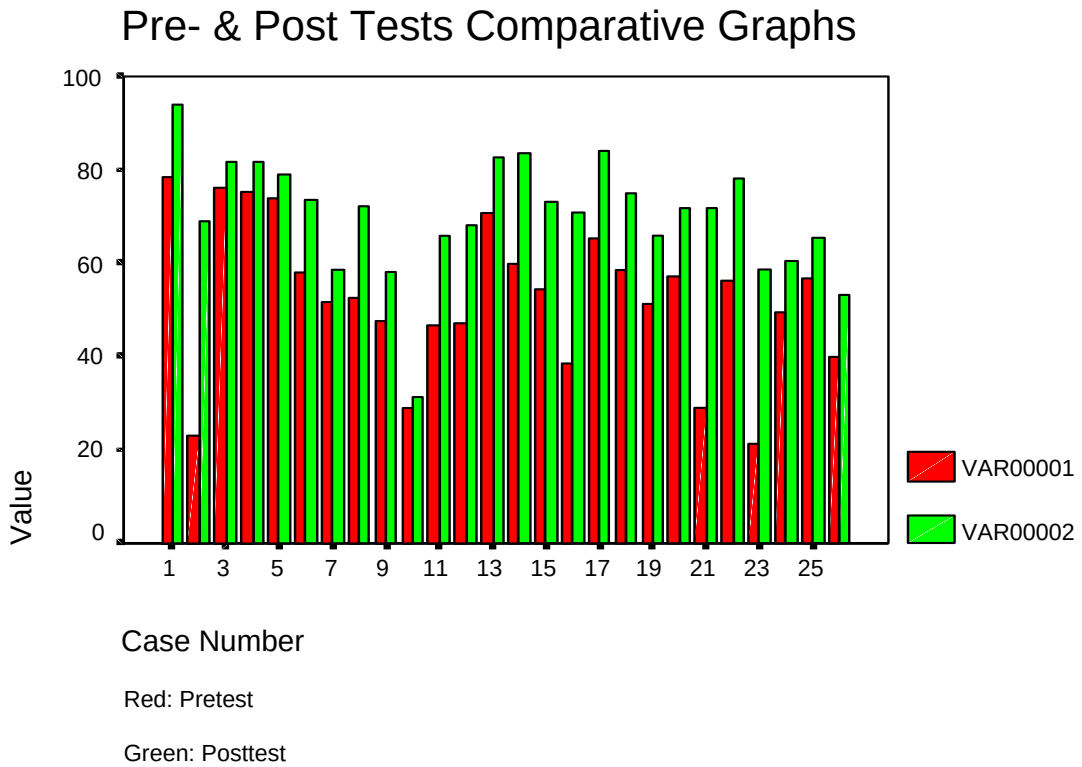
a non-participant colleague of the project of D teacher. A bar graph representing the means of all these pre- and post-tests has been presented in Figure 1 below. However, the mean difference of students' overall pre- and post-tests is statistically significant at p = .000 level (Appendix XVII). Nevertheless, there is a difference of performances among schools. Some schools achieved better than others. Nevertheless, since the teachers constructed the test instruments at their own, one should consider many factors such as history, maturity, testing, instrumentation (the nature of the content and the test items), sample mortality (we lost 8 participants during our follow-up sessions who didn't report any student scores) and regression which might be responsible for single group threat in interpreting these achievement scores. So these findings can't be generalized beyond these samples on individual basis. However, although there was only one case, it is interesting to note that the students' higher mean scores difference of a non-participant teacher of the same school of a participant are not statistically significant. Further research with more similar samples is needed to see if there is any trend of this observation.

Table 1: Students' Pre- and Post-Test/s Scores Reported by Individual Participant Teachers and their Means, Sample Size and Standard Deviation (SD).

Teacher	***Grade Level***	***Pre-test M (%)***	***SD***	***Post-test M (%)***	***SD***	***N***
A	**5th**	**78.50**	**21.35**	**94.30**	**8.7**	**10**
B	**6th**	**23.00**	**16.46**	**69.20**	**16.94**	**25**
C	**8th**	**76.35**	**5.55**	**81.71**	**4.70**	**17**
C_1	**8th**	**75.29**	**5.14**	**81.88**	**7.36**	**17**
C_2	**8th**	**74.00**	**7.41**	**79.29**	**7.10**	**17**
D	**7th**	**58.35**	**27.06**	**73.41**	**18.43**	**17**
D[1]	**8th**	**52.00**	**26.25**	**58.57**	**20.90**	**13**
E	**4th**	**52.55**	**21.09**	**72.16**	**14.14**	**22**
F	**4th**	**47.5**	**14.37**	**58.37**	**18.80**	**16**
G	**5th**	**28.90**	**9.52**	**31.30**	**9.44**	**23**
H*	**3-5**	**47.04**	**22.17**	**66.08**	**17.68**	**23**
H^*_1	**3-5**	**47.17**	**26.08**	**68.22**	**15.34**	**23**
H[1]	**5th**	**70.87**	**15.85**	**82.77**	**16.98**	**16**
I	**6th**	**59.99**	**25.13**	**83.82**	**20.22**	**23**
J	**5th**	**54.72**	**16.22**	**73.05**	**18.72**	**18**
K	**8th**	**38.83**	**27.96**	**70.83**	**15.98**	**18**
L	**5th**	**65.25**	**9.36**	**84.25**	**13.20**	**20**
M	**8th**	**58.58**	**12.64**	**75.00**	**12.84**	**17**
N	**5th**	**51.54**	**9.74**	**65.84**	**8.24**	**38**
N_1	**5th**	**57.31**	**6.57**	**71.64**	**6.92**	**38**
O	**7th**	**28.95**	**12.47**	**71.75**	**16.01**	**20**
P	**5th**	**56.50**	**14.57**	**78.00**	**12.92**	**20**
Q	**5th**	**21.29**	**24.54**	**58.59**	**30.46**	**17**
R	**4th**	**49.67**	**9.26**	**60.33**	**7.31**	**15**
R_1	**4th**	**56.62**	**15.13**	**65.31**	**13.59**	**16**
R_2	**4th**	**39.82**	**11.70**	**53.35**	**11.02**	**17**

[1]**Super Script denotes another non-participant teacher from the same school;**
$_{1\text{-}2}$**Subscript denotes the same participant teacher who administered more than one Pre- & Post Tests;** * Resource Teacher

Figure 1: Graphical Representation of Students' Pre- and Post-test scores on the Content Knowledge



The data provided by the external evaluator in their Table 11.10 reproduced below (This report's Table 2) indicate that it is the participant teachers' perception that their participation in LU project highly impacted the students' increased content knowledge.

Table 2. (External Evaluator Table 11.10). Teacher Perceptions of PD Components that Improved Student Learning

	End of PD program (*n*=13)						
	Frequencies					Descriptive Statistics	
Subject area	U0U	U1U	U2U	U3U	U4U	U*M*U	U*SD*U
Improving my content knowledge	0	0	9	4	0	2.3	0.5
Creating lessons aligned with GLE's	0	3	5	5	0	2.2	0.8
Assessing student learning	0	0	9	4	0	2.3	0.5
Increasing student motivation	0	0	4	9	0	2.7	0.5
Analyzing student performance data	0	1	8	4	0	2.2	0.6
Using inquiry-based/problem-centered teaching	0	0	3	10	0	2.8	0.4
Collaborating with other teachers	1	5	7	0	0	1.5	0.7

Using technology effectively to enhance your teaching	4	5	4	0	0	1.0	0.8
Participating in classroom activities as your students would	0	3	10	0	0	1.8	0.4
Implementing activities in your classroom	0	3	10	0	0	1.8	0.4
Developing materials for use with your students	0	6	6	0	0	1.5	0.5
Managing inquiry-based/problem-centered classrooms	0	5	8	0	0	1.6	0.5

0=none; 1=a little; 2= moderate; 3=high; 4=no improvement in my practice.

Objective 2: To increase 4-8 grade science teacher participants' knowledge and understanding of key concepts in the areas of *Force and Motion.*

Evaluation: To find the extent to which this objective has been achieved we administered one pre-test on the target content using the Test Instrument (Appendix III developed by one of our content instructor, Dr. Dennis) on the first day of our summer workshop. Post test #1 was administered at the end of the Summer Workshop (Level I) and a posttest #2 at the end of the Saturday follow-up sessions (Level III) using the same instrument.

Descriptive Statistics (Table 3) of the raw scores obtained from these tests shows that there was a mean difference (44.48 vs 67.64 vs 67.26) among these tests. Further *t*-test analyses of these three means indicate that the mean difference between pretest and posttest #1 and posttest #2 was statistically significant at $p = .000$ level but that of between posttest #1 and posttest #2 was not significant ($p = .492$) (Appendix XVII). One reason for this non-significant difference between posttest #1

Table 3. Descriptive Statistics: Teachers Content Knowledge Scores.

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	25	18.00	70.00	44.4800	14.5032
Posttest #1	22	45.00	96.00	67.6364	15.8881
Posttest #2	19	42.00	98.00	67.2632	14.3172
Valid N (listwise)					

and #2 might be the sample size difference between these tests. In interpreting this result, it should be kept in mind that there was a sample mortality of 8 teacher participants during our follow-up sessions (levels II and III). Teachers' performances in content knowledge have been represented visually in Figure 2.

From the external evaluator's data provided in their Table 11.5 copied below in Table 4 below corroborate our own evaluation findings on the participant teachers' increased content knowledge. Out of 21 respondent 14 rated their increased content at highest level(3) and 7 rated as moderate(2) and none reported low (1 or none).

Figure 2: Teachers Content Knowledge Performances.

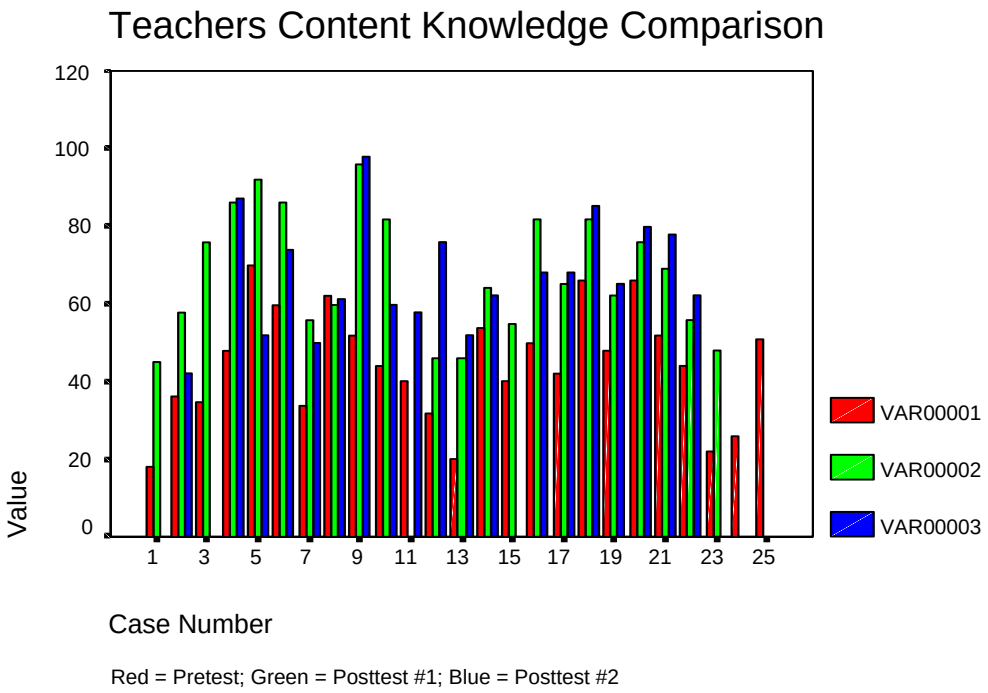


Table 4. (Ref. External Evaluator's LU Project Assessment Document Table II.5): Emphasis of Professional Development Components

	End of Summer Institute							**End of PD program**						
	Frequencies				Descriptive Statistics			Frequencies				Descriptive Statistics		
Subject area	0	1	2	3	*n*	*M*	*SD*	0	1	2	3	*n*	*M*	*SD*
Improving content knowledge	0	0	7	14	21	2.7	0.5	0	1	4	8	13	2.5	0.7
Creating lessons aligned with GLE's	1	1	6	13	21	2.5	0.8	0	1	3	9	13	2.6	0.7
Assessing student learning	0	3	5	13	21	2.5	0.7	0	1	5	7	13	2.5	0.7
Increasing student motivation	0	1	5	15	21	2.7	0.6	0	0	6	7	13	2.5	0.5
Analyzing student performance data	2	4	6	9	21	2.0	1.0	0	2	7	4	13	2.2	0.7
Using inquiry-based / problem-centered teaching	0	0	0	21	21	3.0	0.0	0	0	2	11	13	2.8	0.4
Collaborating with other teachers	0	0	4	16	20	2.8	0.4	0	1	3	8	12	2.6	0.7
Using technology effectively to enhance your teaching	2	9	6	3	20	1.5	0.9	0	5	6	2	13	1.8	0.7
Participating in	0	0	2	19	21	2.9	0.3	0	0	3	10	13	2.8	0.4

classroom activities as your students would														
Implementing activities in your classroom	0	0	0	21	21	3.0	0.0	0	0	2	10	12	2.8	0.4
Developing materials for use with your students	0	2	5	13	20	2.6	0.7	0	0	5	8	13	2.6	0.5
Managing inquiry-based / problem-centered classrooms	0	0	4	17	21	2.8	0.4	0	0	3	8	11	2.7	0.5

0=no emphasis; 1=a little; 2=moderate; 3=high.

It is also evident from the external evaluator's data reported in their table 11.9 reproduced below in Table 5 that most of the participant teachers' confidence level in their content knowledge increased at a significant level.

Table 5. (Table II.9) Confidence in Content Knowledge

	Frequencies					Descriptive Statistics*		
End of Summer Institute	0	1	2	3	n/a	*n*	*M*	*SD*
I am confident in my science knowledge needed to be an effective teacher	0	0	10	10	1	20	2.5	0.5
I am confident in my math knowledge needed to be an effective teacher	0	1	5	5	7	11	2.4	0.7
End of PD Program								
I am more confident in my science knowledge needed to be an effective teacher	0	1	2	9	1	12	2.7	0.7
I am more confident in my math knowledge needed to be an effective teacher	0	0	1	3	8	4	2.8	0.5

Objective 3: To improve 4-8 grade teachers' pedagogical knowledge and practices those utilize SBR findings and best practices of inquiry as an instructional approach to teaching science.

Evaluation: To evaluate this objective, we administered a pre- and post survey on the knowledge and use of inquiry as a science instructional strategy to the teacher participants at the beginning of level-I and at the end of Level III. These surveys were about the participant teachers' understanding and use of 5E hands-on inquiry as an instructional process using a homemade instrument (Appendix V). We used the Likert Scale to assess the objective. Quantitative analyses of these surveys supported that the teacher participants' knowledge, understanding and use of 5E inquiry as an instructional approach to teaching science increased significantly.

From external evaluator's assessment data provided in their Table 11.5 (with scale of 0=no emphasis; 1=a little; 2=moderate; 3=high) presented above in Table 5, it

is evident that most of the teachers in their on-line survey indicated that their pedagogical knowledge and practices increased in comparison to those they possessed before they participated in Lincoln's project. For example, 13 out of 21 indicated that their knowledge on practice of 'creating lessons aligned with GLE's' increased to the high level (3) and 6 to the moderate level (2) and only 1 indicated that his/her a little (1). Same data on the practice of assessing student learning validly indicate that 13 participants' increased to the high level (3) while 5 indicated to moderate level (2) and 3 to a little (1) level. None indicated a 0. Twenty one out of 21 respondents indicated that their ability to use inquiry-based / problem-centered teaching has increased to high level (3). Sixteen out of 21 respondents indicated that can collaborate with other teachers at high level(3), 19 teacher respondents indicated that can participate in classroom activities as their students would at high (3) level, 21 out of 21 indicated that they can implement activities in their classroom at high (3) level, 13 out of 21 respondent participants indicated that their ability increased to the high level (3) in developing materials for use with their students, while 17 indicated that their ability increased to the high level(3) in 'managing inquiry-based / problem-centered classrooms'.

To assess this objective it is also imperative to cite external evaluator's data provided in their Table 11.11 reproduced below in Table 6 to know the extent to which our objective 3 was achieved.

Table 6. (Table II.11) Extent to Which Professional Development Content Influenced Professional Practice

	End of PD Program (*n*=13)	
Aspects of PD project	*M*	*SD*
Content knowledge (improving knowledge about science and/or math)	7.5	1.5
Pedagogy (improving how I teach and interact with students)	8.5	0.8
Instructional materials (developing or revising lessons and related materials)	8.2	1.1
Assessment (developing and using methods for gauging students' learning)	7.7	1.6
Communication/Collaboration/Professionalism (developing working relationships with other PD teachers, instructors, and/or staff)	8.5	1.2

0=none to 10=very much.

It is very explicit from the above data that Lincoln's Professional Development content influenced the participant teachers' increased professional practices at a high to moderate level.

Also the external evaluator's data on participant teachers' satisfaction on different variables provided in their Table 11.6 reproduced below in Table 7 demonstrate that teachers indicated that their confidence increased very much on most of these variables because they participated with LU project. We also conducted a 'Satisfaction Survey' at the end of the summer workshop and the Saturday follow-up sessions using our own instrument (Appendix XV). Analysis of anecdotal data support the above findings of the external evaluator.

Table 7. (Table II.6) Teacher Satisfaction with Professional Development

	End of Summer Institute							**End of PD program**							
	Frequencies				Descriptive Statistics			Frequencies					Descriptive Statistics*		
Subject area	0	1	2	3	*n*	*M*	*SD*	0	1	2	3	n/a	*n*	*M*	*SD*
Confidence in my ability to teach improved	0	0	6	15	21	2.7	0.5	0	1	3	9	0	13	2.6	0.7
I will use/used materials and activities from this project in my classes	0	0	1	20	21	3.0	0.2	0	0	3	9	1	12	2.8	0.5
The summer institute/PD project was relevant to my teaching assignment (for the coming school year)	0	0	2	19	21	2.9	0.3	0	0	2	11	0	13	2.8	0.4
Overall, I am satisfied with my experiences in this project	0	0	0	21	21	3.0	0.0	0	0	2	11	0	13	2.8	0.4

0=not at all; 1=a little; 2=moderate; 3=very much.
*Descriptive statistics do not include "n/a" responses.

Objective 4: To enhance participating 4-8 grade science teachers' use of student assessment data to monitor the effectiveness of their instruction as reflective teachers,

Evaluation: To document the extent to which this objective was achieved, teacher participants were required to maintain a reflective log (Appendix XV)) to note whether their instruction achieved all the lesson objectives and to what extent based on student assessment data. They were supposed to log what they did and how they did, did they need to revise the lesson plan, change the teaching technique and why? Also they were engaged in 'lesson study' research during the summer in which after their lesson, they were given a short amount of time to meet to debrief about the experience and how the teachers thought the lesson impacted student learning. During this debriefing session the teaching teams were also required to rewrite/revise their lessons based on any suggestions they had discussed such as, (1) What level of inquiry the lesson was? (2) What worked well, what did not? (3) What needs to revise for effective learning? What did the peers say about the lesson? Using the peer evaluation form (Appendix XII). Other members of the teaching team then taught the revised lesson to a new class of students in the afternoon. Anecdotal data from these two sources indicate that teachers' knowledge on using student assessment data to monitor the effectiveness of their instruction increased significantly. However, we think that we need to use any standardized instrument/s if there is any to measure this objective more objectively.

CYCLE-4 FINAL REPORT

Objective 5: To improve Lincoln University pre-service teachers' science preparation strategies through improvements in their science content knowledge.

Evaluation: Based on this project's activities and findings, science method curricula for both the elementary and K-12 pre-service courses in the division of education at Lincoln University, were reviewed and modified (Appendix XVIII). Also reviewed and modified was one of the physical science content course curricula that is a prerequisite for our pre-service students before they are admitted to the education program. Another impact of this project on Lincoln University is a yearly event introduced in 2007 on LU staff and faculty Research Workshop Presentation in the campus based on the impact particularly from MDHE grants that LU is receiving for the last four cycles. This event is partly focused on dissemination of the best practices of teaching science aligned with our inquiry (S_bSL) Professional Development (PD) model. In addition, this model has provoked profound interest among educators when it was presented to the division of education faculty. The new conceptual framework of the education division has been designed following this inquiry model as a result.

Lincoln students who declare education as their major, take required science content courses with the department of Science and Agriculture before they can apply for the admission to preservice education program. Dr. Borgwald who has been one of the science content instructor in this project, teaches science content to these students. Prior to his involvement with the Cycle 4, and earlier, workshops for in-service St. Louis public school science teachers, Dr. Borgwald had already developed a series of collaborative group learning projects for lecture sections of all of his introductory physics (PHY 102/102 – College Physics I/II; PHY 201/202 – General Physics I/II) and general education physical science courses (PHY 103 – Earth Science; PHY 105 – Introductory Astronomy). Although some of the introductory physics collaborative projects are mainly aimed at problem-solving, some projects in that course and many of the projects in Earth Science and Introductory Astronomy have some of the characteristics of the teaching methods used in our summer workshops in this project. Most of them are more along the lines of tutorials, and these have more direction in the questions than we use in the inquiry method. The tutorials are often chosen to focus on some of the more difficult concepts in a course. After getting involved in this project he is finding the guided group tutorials to be a more effective method of teaching college level science students.

In the academic year 2006-2007, Dr. Borgwald taught General Physics I and II and Introductory Astronomy. In all cases, he only taught one section of each course per semester, so it was not possible to compare (case study) results from one class using a new method with another section of the same course that was not using the new method. In the first group tutorial in Introductory Astronomy, he had students write their results on white boards to share with the class. Having a large number of students in this course, class discussion usually works not very well, even with just one person representing each group.

In General Physics I, he used the project "Describing Motion" again in the inquiry model, and students shared results on white boards. This was a smaller class, about a dozen students, so it was not too time consuming to share results following the project's consensus building strategy in constructing scientific meaning..

CYCLE-4 FINAL REPORT

In General Physics II, Dr. Borgawald developed a new project in "Electric Potential" that in general began with our inquiry model. Prior to reading textbook material on the subject, they started with an inquiry question, "What is electric potential?" After reaching consensus in their groups, they shared ideas with other groups. Next, they were given some reading on the subject. This was followed by a new look at the question, "What is electric potential?" At this point, the inquiry approach didn't accomplish much because the students quickly grasped what the book said, and they generally parroted back what the book said. It illustrates an important difference between college students and pre-college students. The students who take General Physics have usually had a good preparation in science and math, so they don't struggle as much with some of the basic concepts. The second and third parts of the "Electric Potential" project returned to the group tutorial format with more guided questions to explore some of the more difficult concepts, such as electric potential energy and kinetic energy changes during the motion of electric charges, and the relationship between electric potential and the electric field. Nevertheless, Dr. Borgwald is making a difference in his approach to teaching by gradually adopting our project's inquiry model than the traditional lecture method of teaching.

Objective 6: To improve participating 4-8 grade science teachers' knowledge and skills of science and literacy to improve their students' science reading and writing skills.

Evaluation: To know the extent to which objective 6 was achieved, Dr. Nancy Gammon, the literacy instructor of this project administered a pretest to the participant teachers at the beginning and then a post test #1 at the end of the summer workshop. Finally she administered a second posttest #2 at the end of Saturday follow-up sessions using the same instrument that she developed herself (Appendix V). There were 26 samples who took the pretest and posttest #1 but there were only 18 who took the posttest #2.

The test consisted of three questions which are short answer, essay questions.

The questions were the following:

1. List 3 or more ways in which science texts are different from narrative texts.
2. What instructional strategies might teachers at any grade level use to help students understand science texts?
3. Explain the differences between writing a science report and writing a story.

The purpose of these questions was to help the participants explore the differences between reading science texts and narrative texts; explore the differences between writing science reports and science journals and writing stories; and explore effective science education instructional strategies.

RESULTS:

Question One: List 3 or more ways in which science texts are different

from narrative tests.

Pretest: The majority of the teachers listed the following differences: vocabulary, factual information, different student activities, difficulty level, organization of text, and teacher-centered instruction.

Posttest: There were no significant differences noted between the pretest and the posttest except more teachers noted vocabulary and the use of graphic organizers in the posttest.

Question Two: What instructional strategies might teachers at any grade level Use to help students understand texts?

Pretest: The majority of teachers listed the following instructional strategies: grouping, developing schema, using graphic organizers, using manipulative materials, and simplifying the information.

Posttest: The majority of teachers listed the same instructional strategies as in the Pretest. However, a significant number of teachers included the strategies of grouping and using graphic organizers in the posttest than in the pretest, and listed **inquiry strategies, journal writing, and authentic assessment** than in the pretest.

Question Three: Explain the differences between writing a science report and writing a story.

Pretest: The majority of teachers listed story structure, the scientific process, and factual information.

Posttest: The majority of teachers listed the differences between narrative and expository writing, correctly reporting on the scientific process using factual information, and using scientific vocabulary and terms.

INTERPRETATION OF TEST RESULTS:

According to the test results, most of the teachers understood how science texts differ from narrative texts when they began the Cycle 4 Workshop and maintained that knowledge throughout the workshop. No noticeable differences were reported by the teachers between the pretest and the posttest.

According to the test results, it may be noted the teachers learned more effective as a result of participating in the workshop and became more knowledgeable about the inquiry process, group learning, and the 5E's – Explore, Experiment, Engage, Elaborate, and Evaluate. Differences in the posttest were noted in the teachers' knowledge of authentic assessment and integrating writing into the learning process.

According to the test results, teachers appeared to refine and enhance their knowledge about and understanding of the differences between expository and narrative writing, and integrating writing into science instruction.

9. Description of the project was connected to specific Show-Me Standards, Grade-Level Expectations, and/or curriculum framework

We conducted a need assessment survey of our partners. According to this survey: (a) the teachers are not prepared for the 'No Child Left Behind Act' mandated test in science because schools' emphasis is least on science; (b) most of the students lack ability to extract meaning from text; (c) the teachers are weak in the science strands particularly in physical science; and (d) inquiry strategies are intimidating (none feel comfortable with inquiry-based instruction). These factors determined the focus of our project on 4-8 grade science in *Properties and Principles of Force and Motion* (Strand2) integrated with reading. Accordingly the project was connected to the following specific Show-Me Standards and GLEs.

Show-Me Core Content Strand IV and Curriculum (SC) 2 & 7 (goals 1.1 to 1.3; 1.5 & 1.6; 1.8 & 1.9; 2.1; 2.3 & 2.7; 3.5; 3.6; 4.1); 5-SLPS objectives 06 to 09 for grade 4; SC 2, 7, & 8 (1.1 to 1.3; 1.5 & 1.6; 1.8 & 1.9; 2.1; 2.3 & 2.7; 3.5; 3.6; 4.1); SLPS objectives 08 & 09 for grade 5; SC 2, 7 & 8 (goals 1.1 – 1.6, 1.8, 2.1, 2.5, 2.7, 3.1, 3.3 – 3.6, & 4.6); 5-SLPS objective 01 for grade 6; SC 2, 7, & 8 (goals 1.1 – 1.3, 1.5, 1.8, 2.1, 2.3, 3.2, & 3.4) and 5-SLPS objectives 05 - 08 for grade 7; and SC 2 & 7 (1.1 to 1.3; 1.5 & 1.6; 1.8 & 1.9; 2.1; 2.3 & 2.7; 3.5; 3.6; 4.1);. 5-SLPS objectives 01-03 for grade 8. and GLE Standards: 2.1 A; 2.2A & B, D (4 & 5 Grades); and 2.1A; 2.2 A, B, D. & F (for Grades 7-8); NSES Teaching-A-D; PD-A-D; Assessment-A, - C; Content – levels 4 & 5-8.

10. Dissemination of Project Information:

The project has published as a CD that has been distributed to all the participating teachers and schools by the team. More CDs have been supplied to the school districts for distribution to its other schools/classrooms. A website has also been developed for this project pending the posting by the Lincoln University Office of Information Technology. The director has presented the findings of this grant at Lincoln's Research Symposium on April 12th, 2007and then at the annual meting held by the Missouri Academy of Science at St. Joseph, Missouri on April 21st, 2007. A proposal to present this paper at the state and national level conferences will be made. Loretha Allen, a member of our project team has presented the abstract of this project's findings at the NSTA National Convention at St. Louis, MO held in March, 2007.

11. Conclusions including Lesson Learned

The performance scores and other assessment findings from the participating teachers indicate that they performed better in their content, understood and used inquiry and literacy as a teaching tool of science and used student assessment data to monitor student learning more after the second phase of support-cum-implementation part of this project. It can then be proposed that one shot PD workshop only for few days does not work until a well-planed and sustained support is provided to the participants. Teacher participants in fact expressed more confidence in their content and inquiry-

based pedagogical knowledge in science. External evaluation data corroborate the above claim to a greater extent.

From the above account, this project has much to offer in demonstrating science instructional approaches designed to incorporate important lessons from research on emerging science of inquiry learning which is in contrast to traditional text-book/worksheet-based direct instruction. Inquiry teaching techniques that this project advocated embrace the best practices of teaching science grounded in the principles of 'Scientific Inquiry and How People Learn.' (Bransford & Donovan, 2005). This project's approach to teaching science topics are organized in ways that support students' abilities to (1) learn new concepts and theories with enduring understanding; (2) directly experience the processes of inquiry (including authentic question formulation, prediction-cum-hypothesis generation, modeling, tool use, technology use, and social collaboration) that are crucial facets of the culture of science/learning; and (3) reflect metacognitively on their own thinking and participation in scientific inquiry that transfers the responsibility of learning to them. This project thus has a number of implications for science teachers, parents, principals, school districts and students.

Teachers can benefit from this project by planning their science instruction based on the module used and developed by this project to address students' preconceptions (everyday concepts of scientific phenomena, everyday concepts of scientific methods, argumentation and reasoning and finally conceptual change), knowledge of what it means to "do science", and metacognition that support students to learn new science concepts and theories with enduring understanding. Science teachers who would participate in this PD project would likely understand the principles that drive science instruction and incorporate into their own thinking and teaching and would feel competent and comfortable in bridging their science course/unit/lesson design with emerging research-based general guidelines/principles of learning adopted by this project. This project provides approaches and ideas for science instruction that other teachers may find useful in their own teaching too if understood. In fact, based on our model many of the participant teachers have had their students develop content textbook from the negotiated knowledge constructed via consensus building process in the classroom not only in science but also in other content areas they are teaching.

Parents can advocate this practice of science teaching to support their children's science learning. These techniques of inquiry science teaching need building Principals' support for the teachers to implement into their classrooms. One way this can be achieved is by providing opportunities to the teacher to participate in this type of PD. School districts can also help disseminate this kind of PD among its schools and help sustain PD project ideas among its teachers by providing financial and logistic support to schools. Students, particularly low achievers are the ultimate beneficiaries of this project since inquiry science that follows the principles of learning as incorporated into this project motivates these students and narrows the science learning gaps significantly and help retain these students in the science stream.

Teacher Education program can also implement this project ideas into their preservice science curriculum. This technique can impart the pedagogical and content knowledge of science to train preservice students who in turn are likely to teach their students the way they themselves were taught.

Lessons learned

We learned a number of lessons from during the implementation of the project. First,

there was bit confusion about the selection and purchasing of classroom science materials because the team wanted the need-based wish list from the participant teachers. Consequently there was no consistency in the list and an overwhelming problem surfaced in purchasing from the vendor because the list was endless. The experience instructs us that participant teachers should not be given the absolute authority in selecting science classroom activity materials to avoid delays and stresses in purchasing the classroom science items. Second, the project team should not be so soft to take the responsibility for arranging the classroom mentoring visit rather the responsibility for classroom visits should be imposed on the teacher participants to avoid many frustrations and non-implementation of the objective. More to that issue, the payment and other benefits of participant teachers from the project should be attached as string to this responsibility too. Also it is wise to involve building administrators in selecting the participants so they know that the participant teacher's classroom visit is an essential component of the PD project. To cover more content, 'lesson study' research project should be designed in a way that teachers can use those lessons to teach their peers for reflection than teaching the summer students – the schedule of which sometime is erratic to disrupt the summer workshop.

References:

1. Jonassen, D. H., Beissner, K. & Yacci, M. (1993). *Structural knowledge: Techniques for representing, conveying, and acquiring structural knowledge*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
2. Donovan, M. S. & Bransford, J. D. (2005). *How students learn science in the classroom*. Washington, D.C.: The National Academies Press.

12. Attachments

1. **Appendix I**: Final List of Participants
2. **Appendix II**: Lesson Study PowerPoint
3. **Appendix III**: Summer Schedule
4. **Appendix IV**: Force & Motion Content Test Instrument
5. **Appendix V**: Inquiry Attitude Survey
6. **Appendix VI**: Literacy Pre- & Post-tests Instrument
7. **Appendix VII**: Inquiry Workshop Handout
8. **Appendix VIII**: KWL Chart
9. **Appendix IX**: Concepts treated during the Summer
10. **Appendix X**: Target Content Websites
12. **Appendix XI**: Inquiry Observation Checklist
13. **Appendix XII**: Peer Evaluation Instrument
14. **Appendix XIII**: Instructional (Reflective) Log Format
15. **Appendix XIV**: Saturday Schedule
16. **Appendix XV**: Satisfaction Survey Instrument
17. **Appendix XVI**: SPSS Analyses of Students' Content Scores
18. **Appendix XVII**: SPSS Analyses of Teachers' Content Scores
19. **Appendix XVIII**: EDU 423 Revised Syllabus +

Copy of Compliance Audit Checklist (Original is enclosed with the Final Invoice)