Earth Core: Enhancing Delivery of Geoscience Content in a Diverse School System During Times of Changing State Standards

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ABSTRACT

The Earth Core program provided earth science content to urban public school sixth grade teachers who lacked geoscience training during a one-week workshop with the goal of increasing participants' pedagogical content knowledge (PCK) and confidence in teaching earth science. The workshop evolved from a concern that teachers would not have the training or experience required to engage students with earth science material due to new state standards switching geoscience instruction from 8th to 6th grade. The program, aligned to Cochran's (1992) five suggestions for enhancing teachers' PCK, was set up to encourage participants to reflect by sharing teaching ideas, to discuss what we found to be often naïve earth science conceptions, share lesson plan ideas, and conduct action research. Field trips facilitated a bonding experience that encouraged collaboration of participants, and interactive lesson activities helped participants recognize their limited knowledge of earth science. Both qualitative and quantitative data collection methods were used in a mixed methods approach to this study. Participant confidence in teaching earth science was slightly elevated after the workshop. The study suggests that teachers realized how little earth science understanding they have after being confronted with advanced level geoscience concepts.

INTRODUCTION

A worthy goal for professional development is to enhance teacher's pedagogical content knowledge (PCK). PCK was first introduced by Shulman, 1986; Shulman, 1987; van Driel et. Al., 1998, as a theoretical framework, for understanding the knowledge base necessary to teach. The key elements of PCK include knowledge of the subject material, and understanding of student misconceptions about the content. While most research has focused on how PCK influences the teaching process, little research involves enhancing PCK during in-service programs. Loucks-Horsley, et al., 1998; Loucks-Horsley, et al., 2003; Schuster and Carlsen, 2006, suggest that staff developers with an understanding of adult learning literature ineffectively communicate educational concepts to the content specialists conducting professional development workshops.

The Earth Core program relied on content specialists and adult science education developers co-teach a professional development workshop using Cochran's (1992) four suggestions for teachers to enhance PCK. These recommendations encourage teachers to be more reflective about why specific ideas are taught the way they are, explore in new ways how students think about the concepts being taught, exchange ideas with other teachers about teaching difficult concepts, and conduct action research. The program also aligned to the National Research Council (NRC) science education professional development standards (NRC, 1996), which focus on learning science content through inquiry, integrating science content knowledge with pedagogical knowledge, developing a capacity for lifelong learning, and integrating program components to aspects of school life. Additionally, the National Science Education Standards promote more emphasis on inquiry teaching and learning, integration of theory and practice in school settings, teacher as intellectual, reflective practitioner, teacher as leader, and teacher as a member of a collegial professional community (NRC, 1996; Yager, 2005).

DEVELOPMENT AND CONTEXT OF EARTH CORE

This study was conducted in a large urban system in Georgia, in response to a change in State standards. In 2005, State education standards moved the earth science curriculum from eighth to sixth grade. This change had two significant consequences on the students and teachers. First, students in this southeastern state no longer take a geoscience specific course after 6th grade. Unless students are engaged in the material, it is possible they won't pursue earth science as an elective in high school, or in college. The U.S.is currently at a critical junction in earth science- only 4.6% of all BS degrees in geosience are awarded to African- American and Hispanic students (Strategy for Developing a Program for Opportunities for Enhancing Diversity in the Geosciences, 2006). Therefore, to maintain an essential pipeline of geoscience majors in the post- secondary stream, the curriculum must be engaging in their sole required encounter in the K-12 system. Second, although the standards changed, the teaching staff did not: sixth grade science teachers who formerly focused on life and physical science would now be teaching earth science, with no formal geoscience training. Although Earth science will be taught for two years in both eighth and sixth grades, after this time, sixth grade life science teachers will be the sole contact students have with earth science. To address these issues, we developed a professional development program for these 6th grade teachers named Earth Core, with funding from the National Science Foundation (NSF) - funded Partnership for reform in Science and Mathematics (PRISM)

program. The PRISM program is part of the NSF-funded five-year MSP (Math-Science Partnership). A key feature of prismis the professional learning community (PLC). PLCs were created as a collaboration between urban school district and a local university. The Earth core specific PLC was created in response to the State Performance Standards shift of earth science from grade 8 to grade 6. PRISM PLCs promote collaboration between P-12 teachers and higher education faculty members in order to increase teacher content knowledge in science.

Schools located within the district are involved in the MSP. Considerable professional development has been planned and provided for the system's science and mathematics teachers, and significant curriculum development and alignment are necessary to meet the new science standards. The primary purpose of the professional development agenda is to improve teacher's content knowledge in Earth science, pedagogical skills for inquiry-based teaching and methods of assessing student learning of the geoscience. As such, the Earth Core program was funded from within the MSP/ PRISM funding structure.

The school system is home to 85 schools divided into elementary, middle, and high schools. Approximately 51,000 children attend school in the district with approximately 91% of the population being African American, 6% white, and 3% other ethnic groups. This population is an excellent place to focus pipeline/ retention efforts for the geosciences. Members of the school board, administrators, teachers, and staff members are also largely African American. The teaching population is composed of predominately African American women, who are themselves graduates of the school system (Kozaitis, 1997).

EARTH CORE PROGRAM DESCRIPTION

The Earth Core project had multiple objectives: 1) enhance teacher knowledge through instruction aimed at their level; 2) improve teacher confidence through instruction and training; 3) provide learning and teaching opportunities through hands on inquiry activities that could later be used in classrooms; 4) provide resources to supplement meager existing resources; 5) provide follow-up for teachers throughout the school year; and 6) encourage reflective practice through action research. Teacher knowledge and confidence (goals 1, 2, and 3) were addressed through a week-long workshop that included 2 field trips to examine geology in the field. Materials (goal 4), such as rocks and minerals kits, hand lenses, maps, and resource books, were distributed at the workshop. An instructor was available throughout the school year to answer questions, and a senior undergraduate assistant at a local university was employed to work with teachers and assist with activities in the schools.

Two weeks prior to the week long workshop, participants met at a local mountain that is often a destination for school field trips. While hiking the trail to the top of the mountain, the instructor probed for participants' prior earth science knowledge and presented some background information on structural geology, thereby increasing teachers' familiarity with and ability to use local geology in the classroom. This hiking trip supplied needed feedback for the instructors to design the subsequent workshop based on the prior knowledge and needs of the 6th grade teachers.

The one-week workshop provided participants with content information, opportunities to incorporate instructional materials (such as maps, books, rocks and minerals kits, etc.) to take back to the classroom, a resource disk that matched education standards to instructional lessons, and inquiry activities to do in the classroom. Earth science content covered during the Earth Core workshop included 1) an overview of plate tectonics with subsections on creation of volcanoes, earthquakes, and seafloor spreading; 2) explanation of earth's structure of a crust, mantle, and core; 3) identification and classification of rocks and minerals linked to plate tectonics and earth's structure; 4) fossil identification and classification including identifying function from morphology; 5) ocean and atmospheric circulation and their interaction with the addition of coriolis force; and 6) the influence of planetary rotation on tides. Ideas about how to teach key concepts were shared throughout the week. Participants were given an assignment to prepare and present a lesson to teach a particular concept.

The workshop ended with a second field trip to a local state park. On the way to the state park, the group made several stops to explore the geology of the area and collect rock and fossil specimens. Teachers were given sample boxes and helped to identify and label these materials for use in the classroom. While at the park, participants inquired and discussed earth science topics. Additional resources for the classroom were provided throughout the year.

PARTICIPANTS

Participants were identified by school district administration but participation was voluntary. Of the seven teachers from the urban school system that participated in the professional development workshop, three were African-American female, two were White female, one was East Indian female, and one was White male. One of the teachers had an art degree and the other six had biology degrees. Of the six participants with biology experience, all had certification to teach middle school science and an undergraduate degree while one had a master's degree. The participant with an art degree was not certified to teach science and had no formal science training. None of the participants had formal geoscience training. To protect the anonymity of participants, the name of the school district and identity of participants are being withheld. In May 2005 the group of seven urban teachers, a University geology instructor, a science education doctoral student, and a geology undergraduate student formed the Earth Core PLC.

DATA COLLECTION METHODS

In order to gather data about 6th grade teachers' attitude and confidence in teaching earth science concepts, we used a quantitative instrument augmented by qualitative observations. The data collection included a pre/post survey of teacher attitudes towards science, demographic data, qualitative participant reflections gathered during a reflection session, and researcher as participant observation.

All participants completed a modified version of Weinburgh's (2000) survey of Attitudes towards Science Inventory (ATSI), shown in Table 1, before the first fieldtrip and after completion of the workshop. This instrument was selected due to the high construct validity reported by Gogolin & Swartz (1992) and Weinburgh (1994, 2000). Modifications were made to

Survey of Attitudes Towards Science Teaching

The following statements are about teaching science. Please read each statement carefully. Use the following scale to show how much you agree or disagree with each statement.

If you STRONGLY DISAGREE	X	(2)	(3)	(4)	(5)
If you AGREE	(1)	X	(3)	(4)	(5)
If you are UNDECIDED	(1)	(2)	X	(4)	(5)
If you AGREE	(1)	(2)	(3)	X	(5)
If you STRONGLY AGREE	(1)	(2)	(3)	(4)	X

It is important that you respond to every statement, and that you fill in only one number per statement.

STATEMENTS	Strongly Disagree				Strongly Agree
T1. Science is an important part of the curriculum.	(1)	(2)	(3)	(4)	(5)
T2. I enjoy teaching science.	(1)	(2)	(3)	(4)	(5)
T3. Science should be taught by a specialist.	(1)	(2)	(3)	(4)	(5)
T4. It scares me to teach a new science concept.	(1)	(2)	(3)	(4)	(5)
T5. Students need to receive a broad science education.	(1)	(2)	(3)	(4)	(5)
T6. I enjoyed taking science in K-12.	(1)	(2)	(3)	(4)	(5)
T7. Science is fun for students to learn.	(1)	(2)	(3)	(4)	(5)
T8. I enjoyed science in college.	(1)	(2)	(3)	(4)	(5)
T9. Hands on science activities are too difficult for teaching in the classroom.	(1)	(2)	(3)	(4)	(5)
T10. I look forward to teaching the new science standards.	(1)	(2)	(3)	(4)	(5)
T11. Institutional support for science teaching is high.	(1)	(2)	(3)	(4)	(5)
T12. I feel competent when I am teaching science.	(1)	(2)	(3)	(4)	(5)
T13. My principal/ supervisor encourages me to teach innovatively.	(1)	(2)	(3)	(4)	(5)
T14. I have the budget that I need to teach science well.	(1)	(2)	(3)	(4)	(5)
T15. Parents think it is important that I teach science.	(1)	(2)	(3)	(4)	(5)
T16. I have adequate training and experience to teach Science.	(1)	(2)	(3)	(4)	(5)
T17. Science demonstrations belong in a museum and not the classroom.	(1)	(2)	(3)	(4)	(5)
T18. I wish I didn't have to teach science.	(1)	(2)	(3)	(4)	(5)
T19. Science performance is valued at my school.	(1)	(2)	(3)	(4)	(5)
T20. Teaching science is rewardingl.	(1)	(2)	(3)	(4)	(5)

Demographic Data collected- has not been analyzed for attitude

1. How many years experience teaching?

__ 1
__ 2-4
__ 5-10
__ 11-15
__ >16 _____

2. Gender

__ Male
__ Female

3. What was your
a) undergraduate major?

b) undergraduate minor?

c) graduate education?

4. Ethnic Identity

__ African American/ Black
__ Caucasian/ White
__ Asian American
__ Hispanic/ Latino
__ Multi Racial
__ Other _____

5. In addition to English, do you speak?

__ Russian
__ Spanish
__ Vietnamese
__ Hindi
__ Chinese
__ Arabic
__ Other _____

6. How old are you?

__ less than 25
__ 25-30
__ 31-40
__ 41-50
__ Other

Table 1. Survey of attitudes towards learning science.

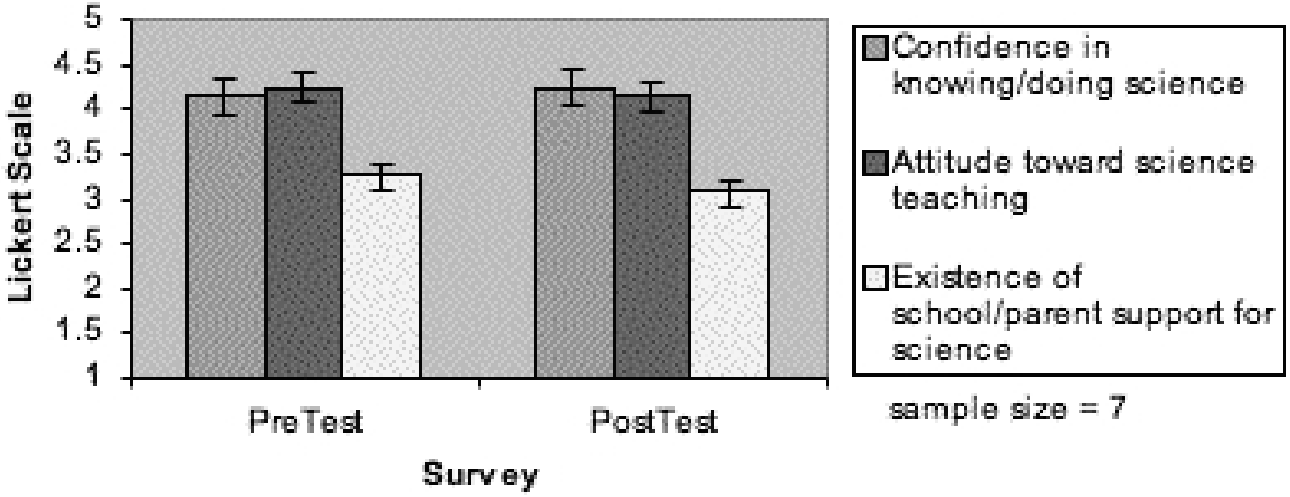

Figure 1. Survey results.

1. As background material was presented during the workshop, did you gain a better understanding of earth science topics?
2. Throughout the workshop week, you engaged in some "hands-on" activities such as constructing geologic time from clue cards and identifying rocks and minerals. How well did you know this information prior to and then after the workshop?
3. During any part of the workshop were new concepts explained to you? If yes, what were they?
4. If new concepts were explained, how do you think your ability to teach these new concepts changed as a result of the workshop?
5. Explain your confidence about teaching earth science and if it changed throughout the workshop.
6. How have (or might) you use what you learned from these activities to increase student learning.
7. What during the workshop helped you most and why? What during the workshop helped you the least and why?
8. Do you keep in contact with other workshop participants for planning purposes? If yes, give an example.
9. Have or will you incorporate parts of the two field trips into your lessons? Explain.
10. Have or will you utilize the EarthCore webpage created for the workshop? Explain.

Table 2. Reflective session questions.

update the language in order to survey science teachers rather than science students and to include demographic data on individuals surveyed. The Weinburgh attitudinal scale was utilized due to its multidimensional nature in order to determine what Earth Core participants believe, perceive, and/or feel about (1) learning science and (2) teaching science. The modified ATSI is a 20-item inventory. The items are scored on a five-point Likert scale to force teachers to strongly agree, agree, disagree, strongly disagree, or indicate indecision for each item. The items address perceptions of the science teacher, anxiety towards science, value of science in society, self-concept in society, enjoyment of science, and motivation of science.

Data from the Lickert scale survey were quantitatively analyzed by calculating the aggregate of participants' responses to questions reflective of particular themes with the values for negative questions being reversed. Descriptive statistics including aggregate numerical mean, standard deviation, and error were performed to graphically represent the quantitative data set from this study.

A reflection session was conducted with participants after the completion of the 5-day workshop in July 2005. A questionnaire, presented in Table 2, was submitted to all participants inquiring as to their experience with the Earth Core PLC, content material, workshop, and fieldtrips. Participants were asked to record their reflections on paper. These open-ended questions added qualitative depth to the survey data and observations. These written reflections were submitted and transcribed for analysis. Teacher reflection session questions (Table 2) were developed and administered in September of 2005. We acknowledge that self reported attitudes and comments are subject to individual participants perceptions of experiences and meaning of the Lickert scale.

Participant observation is a major research strategy which aims to gain a close and intimate familiarity with a given group of individuals and their practices in their natural environment (Merriam, 1998). Such research involved a range of methods: direct observation, participation in the life of the group, and collective discussions. Observations were taken on the fieldtrips and during the workshop. Earth Core researchers documented these observations from fieldtrips and used this data to enrich survey data.

EARTH CORE DATA ANALYSIS

Teachers' pre and post surveys assessed attitudes towards science and confidence teaching science through mixed method data collection. Questions from the attitude survey (Table 1) were grouped based on three commonalities: confidence in knowing/doing science, attitude toward science teaching, and existence of school/parent support for science. The attitude scale incorporated a five-point scale (1=Strongly disagree - 5=Strongly Agree). Item ratings were interpreted for strength of attitude based upon the following scale: 1=negative attitude, 3=neutral attitude, and above 4=positive attitude. On both pre and post workshop surveys, participants showed a mean positive attitude with confidence in knowing/doing science (pre =4.14, post=4.24) and attitude toward science teaching (pre=4.24, post=4.14) and a mean neutral attitude for existence of school/parent support for science (pre=3.26, post=3.08). The quantitative survey data, as shown in Table 3 and Figure 1, do not show a notable difference in

Theme	Survey Question	Mean Value
Confidence in knowing/doing science	4, 7, 10, 15, 17, 18, 20, 24, 25, 26, T4, T10, T12, T16, T18	Pre Workshop Mean = 4.14 n = 7; std. deviation = .44 Post Workshop Mean = 4.24 n = 7; std. deviation = .53
Attitude towards science teaching	2, 3, 6, 8, 11, 13, 23, 27, 28, 29, T6, and T8	Pre Workshop Mean = 4.24 n = 7; std. deviation = .41 Post Workshop Mean = 4.14 n = 7; std. deviation = .40
Existance of school/parent support for science	T11, T13, T14, T15, and T19	Pre Workshop Mean = 3.26 n = 7; std. deviation = .22 Post Workshop Mean = 3.08 n = 7; std. deviation = .36

Table 3. Pre and post workshop survey data.

confidence or attitudes, but this seems not to be representative of the qualitative data from the workshop.

In contrast to the quantitative data, the qualitative initial participant observations from Earth Core instructors noted that participants were interested in increasing their exposure to the content. Participants felt that this exposure would be increased through "pre-packaged materials" which included new textbooks. Participants were generally unaware of their lack of pedagogical and content knowledge within Earth Science. After the pre survey data and observations were analyzed after the first fieldtrip, content knowledge was deemed by instructors to be the most critical area to focus on during the workshop. When asked if gained a better understanding of earth science topics during the reflection session, one participant commented "Not only do I feel like I have a better 'big picture' understanding of earth science, but I also feel that I understand subtopics well enough to do further research to teach it (earth science). Just what I needed before teaching it for the first time." Participants stated that they learned new concepts; one respondent stated "Some of the geology was new to me because it has been more than 15 years since I took geology in college." In other words, at the beginning of the workshop participants did not recognize their lack of understanding of earth science topics. As the workshop helped to improve their understanding, participants recognized their lack of understanding. As the participants began to realize how much earth science they really needed to know, perhaps their confidence in teaching science also slightly diminished. However, we found that through the reflection session participants felt the workshop increased their confidence in teaching earth science. One participant stated, "I feel somewhat comfortable. The workshop helped but I would like to continue with it (learning) throughout the first year of teaching it (earth science)." Another participant commented, "The 'hands-on' activities were extremely helpful for my understanding as well as applicable to my teaching. I would have loved another week of training allowing more time for these types of activities." It appears that the workshop might have slightly improved their awareness of more complexities in teaching the subject matter and at the same time slightly improved their confidence to teach the subject.

On the pre-survey, participants agreed that earth science should be taught by a specialist and on the post-survey they strongly agreed. As we delved into the concepts more deeply, participants began to realize how much they needed to understand before being able to adequately teach the subject. Perhaps they eventually understood the complexities of the earth systems to the degree they now recognize is necessary to correctly teach the subject. The reflection session confirmed that participants were more confident with teaching earth science as a result of the workshop. One participant stated "It (the workshop) helped tremendously; I look forward to teaching them (new earth science concepts) now." Another participant commented, "I feel more comfortable (teaching new earth science concepts)."

The discussion of hands-on activities explored at the workshop provided teachers with an understanding of new ways to think about teaching earth science concepts. Earth Core instructors observed that the teachers were most enthusiastic when engaged in activities designed to help them learn, and which they could modify for their students. The resources we provided for use in the classrooms were also used in the workshop activities. Participants commented that these activities were a valuable resource making comments such as "I will use all of it (activities). The experiences taught me information that gives me a general understanding that will help me plan and teach." From personal experience, participants felt the activities were practical and plan to implement them in their teaching. Teachers were also asked to develop and present a lesson plan for teaching students a new concept, and in the process, learned the value of exchanging teaching strategies. Participant planned to keep in touch with others in the workshop to share lesson ideas.

Also, as shown in Table 3 and Figure 1, on the pre-survey participants felt their school and parents were slightly supportive of science and on the post-survey they did not feel the school or parents supported science enough. Several times during the workshop, participants requested textbooks. During the reflection session, participants again requested textbooks stating, "As we are without textbooks, we are very frustrated with our school, the school system, etc. We really don't know what to do or where to get money to get books. Can you help us?" Since the idea of the training was to promote hands-on inquiry teaching, textbooks were not a recourse instructors were willing to provide. However, NSTA's project earth science series, which is a collection of hands-on lessons to teach geology, atmosphere, oceanography, and space science, was provided to all participants.

The Earth Core program positively impacted teachers' PCK through reflection, exploring how concepts can be taught, and sharing ideas about difficult concepts. While participants' pre and post workshop survey depicts an insignificant change in confidence and

attitude toward teaching Earth science, the reflective session confirms that participants felt more confident with teaching the new curriculum. Participants commented that they would have liked to extend the workshop another week or perhaps throughout the school year. Some comments were "I would have really benefited from two weeks as opposed to the one week," and "…I would like to continue with it (Earth Core) throughout the first year of teaching it (Earth science)." These comments support the participants' preference toward programs designed to increase PCK and the real need for PLCs in targeting teacher's professional development needs.

The design of the earth core PLC included an undergraduate geology major to work with the teachers in their classrooms during the school year. We envisioned that having expertise on hand would enable the teachers to incorporate more creative and engaging activities into their lessons. For example teachers occasionally rely on the rocks in a box approach and don't allow students to bring in backyard samples because teachers do not have the training to identify the samples correctly. This aspect of the Earth core PLC was not realized to its full potential.

CONCLUSIONS

Although our sample is small, anecdotal evidence indicates Earth Core made a positive impact. Teachers were given the chance to move beyond their routine approach to earth science- the handout. Our workshop provided them with the materials to incorporate rocks and minerals, not just written descriptions, into their classrooms. The AST materials will allow them to provide strong content-based materials, particularly in a school system that did not purchase new, age-appropriate textbooks to accompany the change in standards.

The pre and post-test survey along with the reflective session suggest that the workshop increased teachers' PCK. The informal learning environment of the first field trip helped participants to get to know each other and feel comfortable with sharing their ideas. Through open discourse with the instructor during content dissemination, participants reflected on their own naive understandings of earth science. This helped them to better understand their students' misconceptions. Asking participants to create and share lessons to teach new concepts covered during the workshop encouraged continued sharing of ideas during the school year, and the reflective session revealed that participants were sharing lessons between participants within the same school.

We recognize the limitations of the survey, which included up front placement of demographic data, and the lack of questions concerning the participant's interest in the outdoors. We understand that a new survey is currently being developed for teachers participating in the NSF/OEDG funded Oceans of Opportunity program (see Pride et al, this volume.) in conjunction with the American Institute for Research (AIR). This new survey uses a different approach to collect demographic data and incorporates participants' interest in the outdoors. We recommend investigating the design of this survey to address the limitations of our survey on the science teacher's attitudes towards science,

Throughout the workshop, instructors implicitly incorporated Cochran's (1992) recommendations for enhancing teachers' PCK. Participants were encouraged to be reflective during the workshop by sharing ideas about teaching specific concepts. Naive conceptions that students might have about certain topics were discussed especially when other participants held theses same misconceptions. Making explicit why students have misconceptions and how prior knowledge interferes with student understanding further increased teachers' PCK. Ideas about how to teach key concepts were shared throughout the week. Participants were given an assignment to prepare and present a lesson to teach a particular concept. Participants were encouraged to do action research throughout the school year and share their work at the national geoscience conference. While a few of the participants expressed an interest in the idea and may have informally engaged in action research, none of the participants formally submitted an action research project. Setting up a specific action research plan prior to the end of the workshop could increase teacher's formal participation in such a project. Another recommendation is for instructors to maintain weekly contact with teachers throughout the school year finding out when certain topics are to be taught and visiting the classroom. By doing this, university instructors can offer teachers just in time delivery of key instructional methods and activities.

The authors acknowledge that a key finding of this study is the insight into the confidence level of 6th grade teachers with limited geoscience training. While survey results indicate a neutral to slightly elevated confidence level after the program, this does not explain the phenomenon of teachers recognizing their own content deficiencies upon experiencing geoscience concepts at an advanced level. The study suggests that until confronted with deeper content, teachers do not understand how little they know.

Participants expressed an interest in extending the program throughout the school year, at least during their first year of teaching the new curriculum. The National Science Education Standards (1996) advocates for long-term coherent professional development plans. Along with providing assistance to participants conducting action research, conducting follow-up sessions throughout the school year is recommended. These follow-up sessions can provide an opportunity for participants to share their first time experiences in teaching the concepts and expose them to additional ways of presenting the material. While the one-week workshop focused explicitly on geoscience content and implicitly on pedagogy, the follow-up sessions could be designed to explicitly focus on the pedagogy and review of the geoscience content.

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