A Technology Supported Multi-Sensory Approach To Science Teaching Model

Prof. Gouranga Saha
Professor of Science Education
Lincoln University of Missouri
Jefferson City, Missouri 65102-0029, USA

Abstract

Classroom teachers' fears of science and abhorrence of technology integration particularly limit their ability to foster scientific literacy for all students. This study aimed at enhancing the quality of science teachers' pedagogical content knowledge via a professional development (PD) intervention employing a technology-centered inquiry science teaching technique. Twelve science teachers from Mid Missouri participated in this study. Pre- and post-test and anecdotal data analyses indicate that participant teachers' attitude towards inquiry science and science knowledge increased significantly from this program. In addition, these experiences have had a long-term impact on these teachers' confidence and comfort levels to implement technology-infused inquiry science instruction in their classrooms that their students find interesting and meaningful. Limitations and opportunities for further research are discussed.

Key words for the Paper: *Inquiry, Technology, Multimedia, Evidential basis of knowledge construction, reasoning,*

Of all authors and acknowledgements: *Scientific literacy, Integrating cognitive theory and classroom practice, student teacher role identity and practice, pedagogical context knowledge, teachers knowledge, types of inquiry, 'golden standard' of research, Teachers' beliefs, performance-based assessment, teachers' knowledge.*

Purpose

The immediate objective of this research was to develop a model for technology supported multi-sensory approach to science teaching to answer the question, whether technology-supported inquiry science pedagogy promotes positive attitude and inculcates a long-term experience for sampled in-service science teachers. Another corollary objective of the study was to measure the extent to which these teachers transfer this experience into their science teaching process.

Introduction

A nation-wide survey conducted recently *(NSF, 2000)* identified that an alarming number of elementary teachers don't feel qualified to teach science. Strength of the science education program in our neighborhood schools may not be different from all the observations that the above study cited.

Recent as well as the past data support the reality that most of these teachers have had limited exposures to science as undergraduates and in their professional training *(Weiss, 1987; Arons, 1983; Wallace & Louden, 1992; Irving, Dickson, & Keyser, 1999; Gess-Newsome, Barnett, & Hodson, 2001; Ridgen, 1999; Lowery, 2002).* Whereas science and technology are increasingly becoming interdependent and mutually reinforcing aspects of natural and physical world, many of them fail to use technology to support their instruction. Research indicates that computer technology can help support learning, and that it is especially useful in developing the higher-order skills of critical thinking, analysis, and scientific inquiry *(Roschele, 2000)* to meet the complex demand of the current workforce.

Introduction

Weaving the benefit of 21st century technology into science curriculum will ultimately help us meet of this changing world. In order to achieve the national goals of scientific literacy and much needed evidence-based reasoning skills, our children not only deserve science teachers who understand what they are teaching; they deserve science teachers who know how to teach science.

Although there are many studies out there on inquiry-based science teaching, very few have focused on multisensory technology-integrated inquiry pedagogy in science.

Three questions that guided this study are:
1. Can professional development program be designed to increase the participating teachers' understanding of inquiry as an instructional approach to teaching science?
2. Do inquiry science teaching strategies supported by computer technology including the Internet, Web-based resources (visualization) and multimedia authoring program strengthen science content knowledge of in-service teachers? and
3. Do above strategies have a long-term impact on teachers' ability and confidence levels to implement technology-infused inquiry science instruction in their classrooms that their students find interesting and meaningful?

Samples

Thirteen teachers from four county public and parochial schools of central Missouri participated in this project-based study. It's a non-probability sample of convenience.

Procedures

(1) First a summer course was designed and implemented with workshops on the concept of inquiry as an instructional approach to teaching science followed by group discussions, so that the participant teachers themselves could experience, "what it means to learn science through inquiry and what it needs to set the stage in creating an inquiry-based science learning community in their own classroom" *(PBS, 2001)*. Led by a PowerPoint presentation, an interactive discussion was focused on the characteristics of a "do-able" *(Saha, et. al – under review)* performance-based activity.

(2) The participants were then provided with resources – textbooks, web sites, etc. to identify the task-oriented concepts/ideas of the big picture of each of the target content areas (such as *inertia*, *mass* & *weight*, *speed*, *velocity*, *acceleration, friction*, *gravity, etc.* for the big picture of 'motion.'). Brown and Campione (1994) recommend that to cover the course requirements of their schools, teachers should choose the main themes and students should be encouraged to select specific topics within those themes to reduce the time intensity in facilitating inquiry in science education. For example, it was a guided step/stage meant to develop a *learning structure* for the lesson on 'motion' – so that logical progression of ideas is conveyed *through task-relevant remediation process.* During the process, participants were familiarized with "How to develop and validate science tasks/ activities" *(Saha and Doran, 2009).*

Procedures

(3) Next, under the guidance of an experienced faculty, the participants conducted inquiry activities on each of the targeted physical science concepts in a manner that they are exposed to three types of inquiry outlined by Martin-Hansen (2002) – *open or full inquiry*, *guided inquiry*, and *coupled inquiry*. However, emphasis was given on regular *structured inquiry* (a guided inquiry mainly directed by the teacher) that leads to a stronger inquiry-oriented science teaching identity *(Eick & Reed, 2002).*

(4) After an investigation was complete, the participants working in groups created a claim and an explanation of the claim based on observational data (evidential basis of conclusion/inference). All the groups shared their claims and findings regarding their inquiry. To avoid hypothetico-deductive mode for doing science a consensus building process ensued after examining whether contemporary accepted view on the target science concepts supports their claim or explanation.

(5) To draw a mental map (a metacognition process) and provide further cue, the instructor took them to selected Internet sites for web-based visualization/ simulation of the concept.

(6) In addition, a streaming video on the concept was shown to reevaluate or reinforce the concept/s that they explored themselves and made the claim based on their own observational data.

(7) Finally, the participant teachers were directed to create presentations of the concept knowledge they just claimed using multimedia authoring program "Hyper-Studio." The product they created in this technology frame helped them take the responsibility and claim the ownership of their own learning.

Results

R/Q 1 **-** A pre and post-tests results conducted on the participant teachers' conception about inquiry and their attitude to inquiry science produced a non-significant '*t*' (*p* value of 0.872 - 2-tailed). One possible reason for this non-significant '*t*' might be that in addition to only a very small number of test items (only 7) used to assess this element of the test, the test items belonged only to the 'knowledge' level of the inquiry cognition that might have resulted in almost the equal mean (pre- 5.1 and post- 5.2) for both the pre- and post-tests. Another reason might be due to resiliency of the belief system to change *(Pajares, 1992)*.

A comparison of scores using a dependent (paired) *t*-test ($\mu \neq 0$) showed a significant difference between pre- and post-test scores (p value of .004 – 2 tailed).
These positive statistical results were supported by the participant teachers' journal entries, formal reflections and the end-of the summer course evaluation feedback, such as-

> *"Inquiry teaching is very student oriented … I would like to add more this type of ngaging [science] activity to my class." "As for inquiry learning, the students really enjoy it. … They are excited". "The [inquiry] video segment we watched and discussed today helped to answer some of my questions on [effective] science teaching."*

Results

R/Q 2: A comparison of scores obtained from the pre- and post-tests administered over the content specific knowledge in the areas of *matter and energy*, *force and motion*, and *electricity and magnetism* and their ideas about the products (scientific facts, concepts, generalizations and principles) of 'doing science' related to construction of science knowledge from inquiry-oriented science instruction in the classroom using a dependent (paired) *t*-test ($\mu \neq 0$) showed a significant difference between pre- and post-test scores (p value of .002; 2 tailed).

These positive statistical results were supported by the participant teachers' journal entries, formal reflections and the end-of the summer course evaluation feedback, such as-

"We.. performed activities on matter; we made observations and inferences about different types of matter and discussed inferences. "I felt very comfortable doing the calculations and activities. I may use activities shown in these classes." "My students would enjoy this activity." "I believe the Internet resources are a good source of demonstrations and activities."
"I understood the [targeted] physical science concepts covered …"
" I have never used the rheostat [in electric circuit] before and enjoyed the lab." I enjoyed developing Hyper Studio projects."

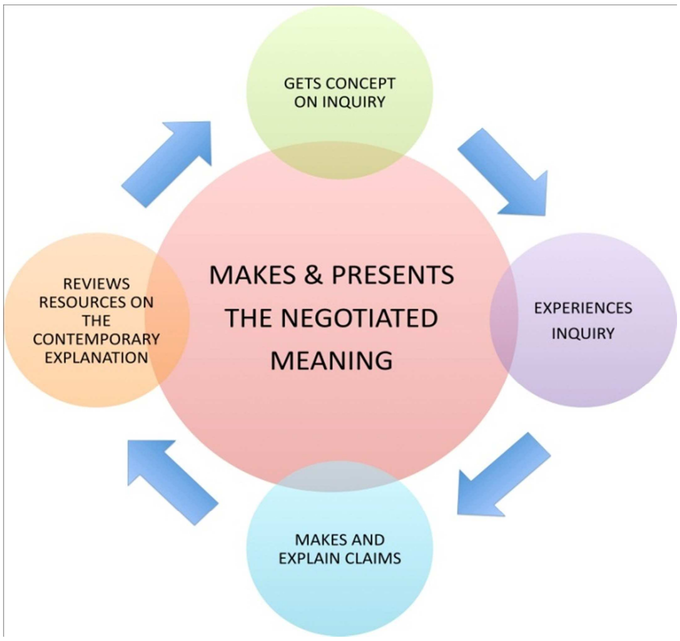
R/Q 3: As a part of the summer course assignment the participant teachers developed inquiry units on the targeted content areas. Many of them implemented these units using the techniques and strategies they learned during the summer course to teach technology-supported inquiry science in their classes. Reflective journals of the participating teachers and their students indicate that the strategies used by this PD had a long-term impact on teachers' ability and confidence levels to implement technology-infused inquiry science instruction in their classrooms that their students found interesting and meaningful.

"All of the students agreed that they definitely preferred inquiry science to the alternative of book learning." [In an inquiry science lesson] you can see [observe] what happens and you can remember the results [conclusion] better."

"They [students] have designed experiments of their own inquiries and performed the experiments … during their study times. The students' enthusiasm has even convinced my co-workers to come and observe the experiments! ("We just had to come and see what all the kids are talking about."). Parents have even gotten involved and come to class to see their child perform self-designed experiments. (As one parent said, "I can't believe she actually likes science! But, we never did stuff like this when I was [sic] in school")

Results

The Model proposed by this study is presented below graphically:



This model rejects the notion of science as a stepwise process and includes highly empowered steps of doing science for understanding. In summary, it suggests that supported by technology, inquiry science teaching and learning should begin from scientific question, provide evidence to answer the question in constructing knowledge.

Discussion

A good number of reports and concerns have clearly demonstrated that the health of USA scientific and technological pre-eminence has been weakening in comparison to other nations in the world. All these discouraging trends in standardized test scores, students' abhorrence in science, technology and mathematics (STEM), a lack of self-reliance among teaching community in many schools, demand different approach to teaching and learning. Technology in particular multimedia that incorporates text, audio, video, simulation and images in the same document plays vital **roles** in **teaching** procedural knowledge in STEM education (Lin et al., 2014). This study also provides empirical evidence that when appropriate technology is used to support instruction, all students' curiosity invigorates undivided attention to their learning. Leow, and Neo (2014) also found that when inquiry technique combines multimedia technology, it fosters education innovations as alternatives to the conventional classroom teaching and **learning** methodology.

Nevertheless, though the sample size is typical of similar in-service program, the findings of this research can't be generalized to a wider population because it was too small (and so the effect size) and not randomly selected. In addition, if feasible, a controlled experiment should be conducted to attain the 'golden standard' of research advocated by the Department of Education's No Child Left Behind (NCLB) USA Act of 2001.

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