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The Right Stuff: Inquiry Training, Teaching & Transfer for Content Mastery in the Sciences

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INTRODUCTION

The standardized testing movement has inadvertently placed pressure on elementary and secondary instructors to teach to the test. Primarily this is manifested through memorization and testing skills training and less on developing content mastery and problem solving. Hands-on activities (also referred to as inquiry learning) are lauded by the literature as an effective methodology in the development of content mastery (Akerson, V., Hanson, D., & Cullen, T.; NSF, 2010; Smith, T., Desimone, L., Zeidner, T., Dunn, A., Bhatt, M. & Rumyantseva, N., 2007). Nevertheless, administrators often see the inquiry method as an ineffective use of classroom and training time diverting attention away from test preparation. The research abounds, however, regarding the positive influence hands-on/inquiry-based learning can have on testing results (Cuevas, P., Lee, O., Hart, J. & Deaktor, R., 2005; Marx, R., Blumenfeld, P. C., Krajcik, J., Fishman, B., Solomay, E., Geier, R. & Tal, R. T., 2004; Stohr-Hunt, P. M., 1996; Ruby, A., 2006; and Ashman, S., 2007).

External pressure to perform on high stakes tests has not been the only thing diverting teachers from utilizing this instructional method. The literature repeatedly cites three additional roadblocks to its usage (specifically in science education): lack of science pedagogy, material needs, and deficit content knowledge (Davis, E., Petish, D. & Smithey, J., 2006; and Hernandez, P., Arrington, J., Witworth, J. 2002). Effective science pedagogy has long been identified as a problem in secondary education where content knowledge abounds (Loucks- Horsley et al., 1998; Luft, 2010; and O'Brien, 1992). On the other hand, elementary instructors are more likely to embrace wide ranging pedagogical styles, but often lack content knowledge (Akerson, 2005; Akerson & Flanigan, 2000; Borko, 1993; and Dickinson, Burns, Hagen, & Locker, 1997).

These hurdles along with pressures to "teach to the test" often limit exploration and experiences involved in effective inquiry learning that facilitates deeper levels of content mastery (Ruby, A., 2006; Stohr-Hunt et al., 1996). The current study looks to address the role inquiry-based staff development can play in minimizing these internal hurdles at the elementary and secondary levels; to increase support for inquiry-based methods in staff development, and therefore improve content mastery and achievement in science.

Problem

Science education has taken an especially harsh hit in part due to focus on teaching to the test and less classroom experience with inquiry practices. The National Science Board released a research study identifying disheartening findings in our nation (2010). Secondary math and science scores across the board are on the decline. Interestingly, this same study found primary scores on the increase.

While NCLB (No Child Left Behind) expects increased rates of knowledge attainment as measured by state standardized tests, many states have been accused of lowering standards to attain these score increases. Analysis of TAKS (Texas Assessment of Knowledge and Skills) science scores from 2006 and 2009 reveals a decline in expectations in secondary science education (TEA, 2010). The science portion of the TAKS (taken in 5^{th}, 8^{th}, and 11^{th} grade) requires a score of 2100 as the "recommended" passing standard. While the same score is necessary in each of the testing grade levels, the number of questions and question weights differ, requiring a lower percentage of correct answers for the older grades. In fifth grade students must answer 75% of the questions correctly; however, eighth grade students need to score 66% to pass and the eleventh grade TAKS requires only 55% of correct responses (see table 1). The increase in statewide student pass rates from 2006 to 2009 (see figures 1, 2, & 3) at the secondary level holds much less meaning when this is considered.

Table 1

TAKS Scoring Standards: A Comparison by Grade Level

	2006		2009	
Grade Level	Recommended	Commended	Recommended	Commended
5^{th}	30/40 (75%)	37/40 (92.5%)	30/40 (75%)	37/40 (92.5%)
8^{th}	27/50 (54%)	44/50 (88%)	33/50 (66%)	44/50 (88%)
11^{th}	29/55 (53%)	49/55 (89%)	30/55 (55%)	49/55 (89%)

Note. Scoring standards were retrieved from the Texas Education Agency website. Recommended refers to the passing standard (or a score of 2100) and commended refers to the score needed for exemplary recognition on the TAKS science exam in correlating grade levels.

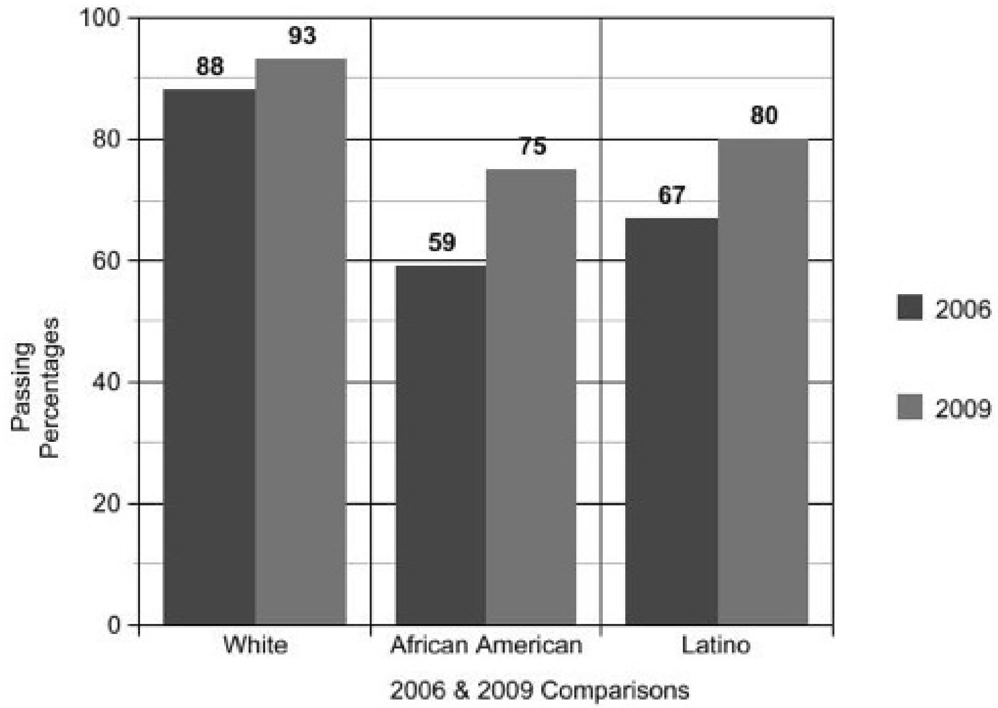

Figure 1. TAKS Passing Rates for 5th Graders by Ethnicity

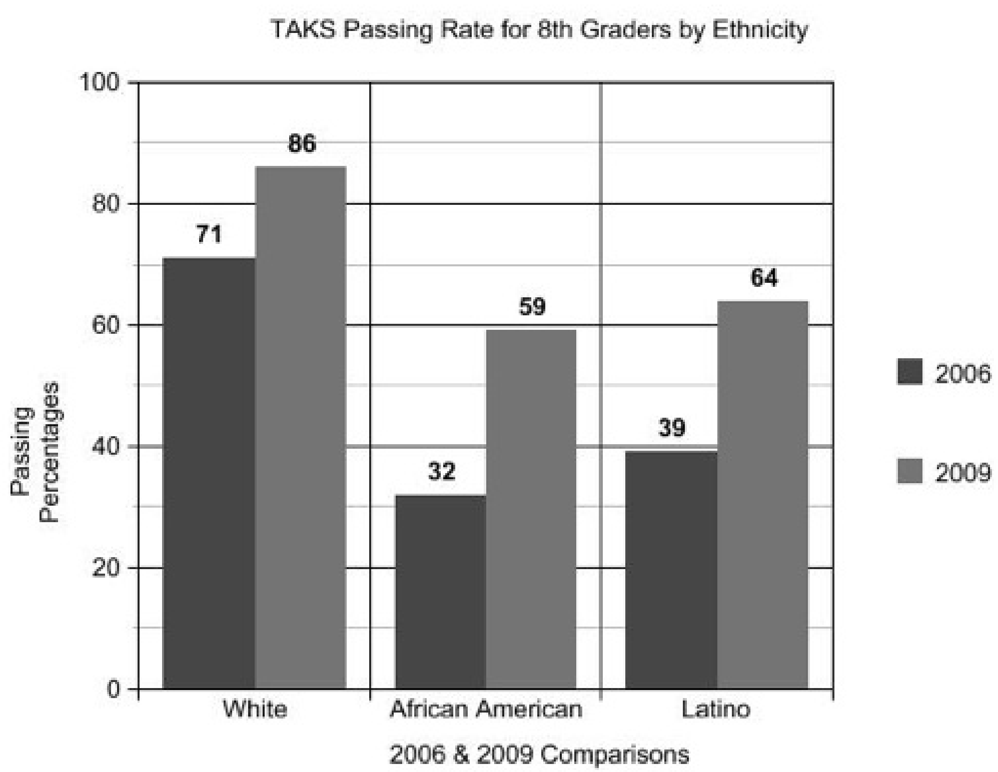

Figure 2. TAKS Passing Rates for 8th Graders by Ethnicity

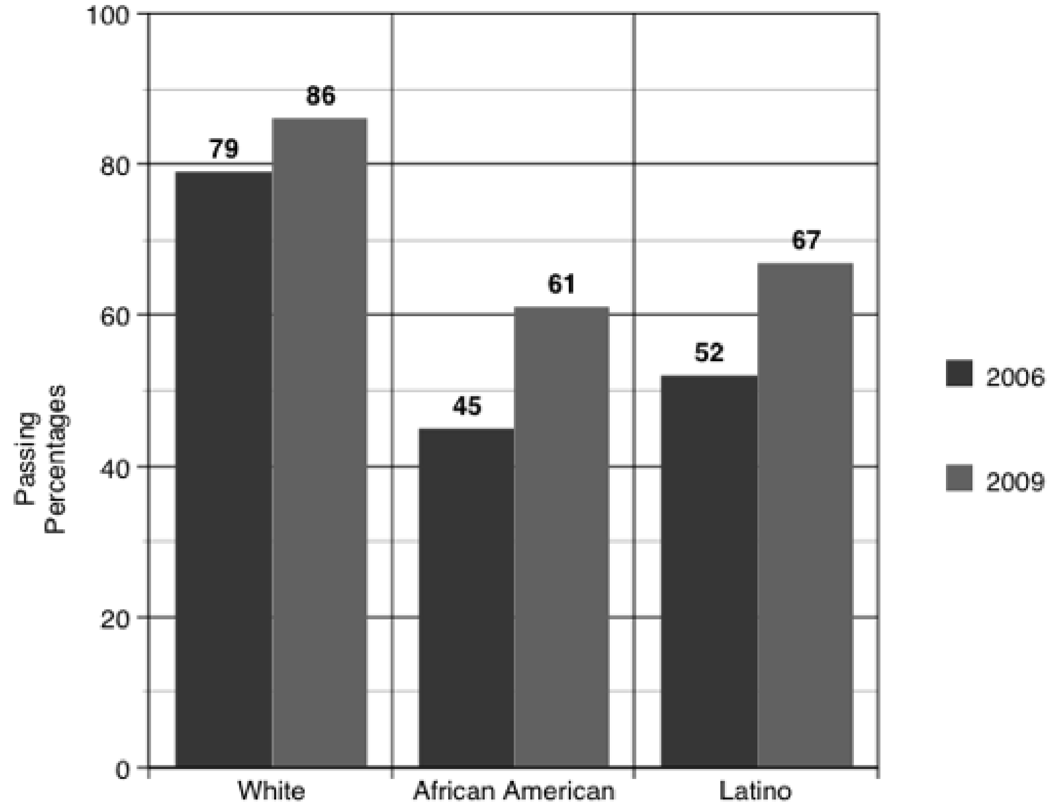

Figure 3. TAKS Passing Rates for 11th Graders by Ethnicity

Lowering standards and the secondary performance decline found by the National Science Board begs the question: what is or isn't happening in the classroom at the secondary level to impact content mastery? Secondary schooling itself becomes increasingly more content specific and focused in particular areas later in students' educational career. Seemingly, this means more depth in the content areas; however, the lower standard for upper grades and higher pass rates of Texas 5th graders does not support this. The findings do support the idea that upper level students could be receiving much breadth, but not the mastery of content needed for application or problem solving type questions (such as those found on the TAKS exam) that inquiry methodology could provide (Marx et al., 2004; and Davis et al., 2006).

Generally speaking, secondary science instructors are required to employ labs and hands-on experiences with the subject matter. According to the literature, however, inquiry learning at the secondary level is not occurring. Valli and Buese (2007) found secondary science teachers often demonstrate the same rigidity during labs found by those focused on "teaching to the test", treating labs as a "lock-step" activity that cannot be veered from. Windschitl (2003) also found that secondary science teachers tend to view inquiry as linear, science with steps if you will. Inquiry learning, however, is active learning assessed by students' experimental and analytical proficiency as opposed to how much knowledge they possess. Unfortunately, instruction in inquiry methodology is often not a part of a secondary science teacher's preparation at the college level. In addition, many secondary administrators mistakenly believe that if the students are doing a "lab" then they are participating in inquiry learning. The misconception is that if students are in the laboratory then they are "doing inquiry." The fact is that inquiry, as a method of instruction, must be learned for facilitation in the classroom. It is *not* inherent just because the students are using materials or conducting an experiment. “To teach inquiry-oriented science as recommended by current reforms in science education, a teacher must hold strong understandings of and abilities with regards to science inquiry” (Davis et al., 2006, p. 615). First and foremost, facilitation of inquiry methodology requires pedagogical training. Such training is not often utilized at the secondary level (Loucks- Horsley et al., 1998; Luft, 2010; and O’Brien, 1992).

Staff Development to Facilitate Inquiry Methods

The research over the years largely identifies major areas that make for the most effective professional development such as that needed for inquiry training (Smith et al., 2007; Akerson et al., 2007; NSF, 2010; Banilower et al., 2006; Clewell et al., 2004; and Hernandez et al., 2002): 1) emphasis on content knowledge, 2) connection to teacher instructional requirements, 3) mentoring, and finally, 4) opportunities for participants to learn materials in a hands-on approach. These professional development components have translated into increased student achievement and teacher efficacy (Banilower et al., 2006; Correnti, 2007; Heck, Rosenberg & Crawford, 2006; Shimkus & Banilower, 2004; and Wenglinsky, 2002).

The Environmental Education Initiative

The Environmental Education Initiative (EEI) is a program funded by the city of Dallas, which purposes to increase public awareness and action surrounding water conservation and recycling issues. A large portion of the grant was focused on developing inquiry lessons that would flow into stipulated science curriculum for elementary schools. The efforts by and large have been directed at Dallas teachers and school children. The standards aligned spiral curriculum provides hands-on, guided inquiry-based, science lessons regarding water conservation and recycling for Kindergarten through 8th grade. EEI uses a multitier approach to attain student content mastery in both water conservation and recycling education.

EEI Staff Development Overview

The EEI grant also provides staff development that: 1) equips teachers with content information about water conservation and recycling, 2) provide hands-on science lessons *and* the materials to conduct the lessons in the classroom, and 3) allows for teacher participation in the hands-on inquiry-based science lessons during the staff development. Additionally, the grant provides interested teachers with the opportunity for a master science teacher to model the hands-on science lessons in their own classroom with their students. Each of these elements was designed to address components the literature identifies as roadblocks to hands-on science instruction (Hernandez et al., 2002).

This study focuses on the effect the EEI staff development had on participating teachers’. Specifically, the study attempts to determine which, if any, of the in-service components (information, lessons, materials, and/or hands-on training) had an effect on teacher usage of the inquiry-based lessons in their classrooms; i.e. Transfer from staff development to classroom use.

Method

In-Service Evaluation

Two forms of data were collected to determine the impact of the EEI staff development. The first was an on-site participant evaluation (n 433). Within the evaluation, teachers were asked to identify in their own words the most useful component of the professional development they participated in. Five focus categories emerged from the participants' responses to this component of the evaluation. The five areas identified focused on: 1) information received, 2) materials received, 3) written lessons received, 4) inquiry-based training received, or 5) no focus identified (i.e. statements such as, "Everything was great!"). Each participant's response was coded by five independent raters as focused in one of these five categories. The raters were instructed to categorize each teacher's response to this question based on the perceived focus of their statement. For instance, if the written statement seemed to focus on the information the teacher received at the in-service, the statement was coded as information received (i.e. "Until now I didn't know what Dallas recycled. Very interesting.") Statements focusing on the hands-on nature of the in-service were coded as inquiry-based training received (i.e. "I really liked doing the hands-on lessons, it makes taking the training into my class easier!"), and so on. To ensure inter-rater reliability the scores assigned by each rater's scores were run against the others to ensure that there was a high correlation between raters' scores. The statistical analysis revealed that the raters' scores were highly correlated with an adjusted r of .965 ($p < .001$)(See Supplementary Files for correlation of researchers' rating scores). After the inter-rater reliability was established, the mode of the five raters was taken for each participant and used to categorize participants' area of focus into one of the above-mentioned categories.

Anonymous Survey

The follow-up survey looked to establish what components of the in-service were/or might be transferred into the classroom. The survey was sent by email to previous in-service participants. The email had a link embedded in it leading the user to an anonymous on-line survey. The responses to the survey were linked to participants' original evaluations and therefore their original focus as identified by the raters (names were removed, and participant numbers assigned to ensure anonymity). The survey asked questions about teachers' inclusion (or potential inclusion) of received information, materials, and/or lessons in their classrooms.

Some interesting findings emerged from the analysis of the two measures.

Findings

The In-Service Evaluation Analysis

The onsite in-service evaluations themselves revealed that a large majority of teachers found the hands-on nature of the in-service most useful (n 181). Next, participants identified the written lessons as the most useful component they received (n 96), followed by the lesson materials provided to them (n 78). Only 14.5% (n 63) of the participants identified the information as the most useful aspect of the session. The remaining teachers did not identify any particular component, writing generalized comments such as, "Everything was great!" or leaving this question blank (n 16). (See figure 4 for the breakout by percentage.)

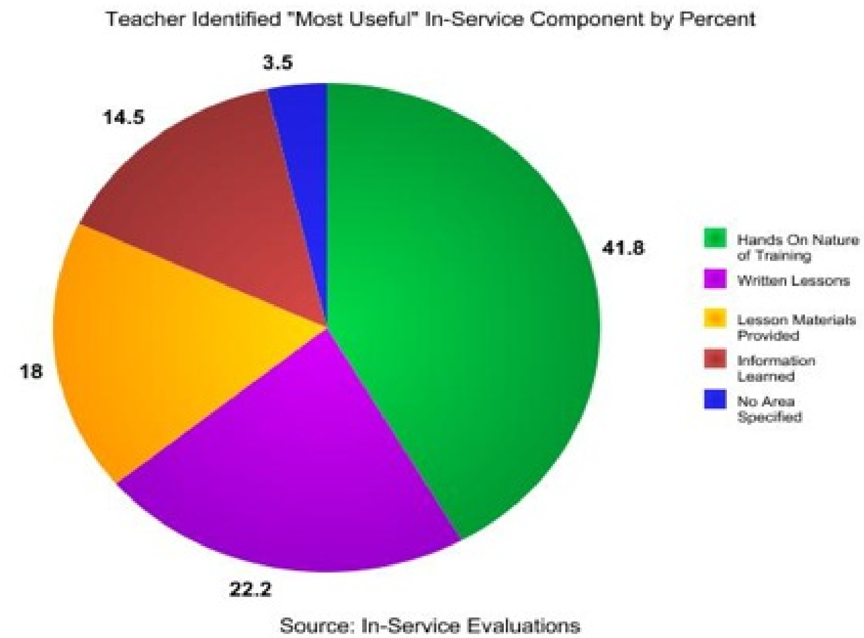

Figure 4. Teacher Identified "Most Useful" In-Service Components by Percent

On-Line Survey Analysis

While the teacher participants, by and large, identified the hands-on nature of the in-service as the most useful component on the original evaluation, the analysis of the on-line survey revealed something different. No statistically significant difference between the identified categories (lesson usage, materials and/or information) was found. The actual use of materials and the hands-on lessons were roughly the same, while the information received at the in-service was only slightly higher in regards to classroom transfer (See Figure 5).

Further analysis revealed a participant transfer rate of 72.17% or greater in each area [previous (R), current (C), or potential (p) use of the information, materials and/or inquiry-based lesson] into the classroom (See figure 5).

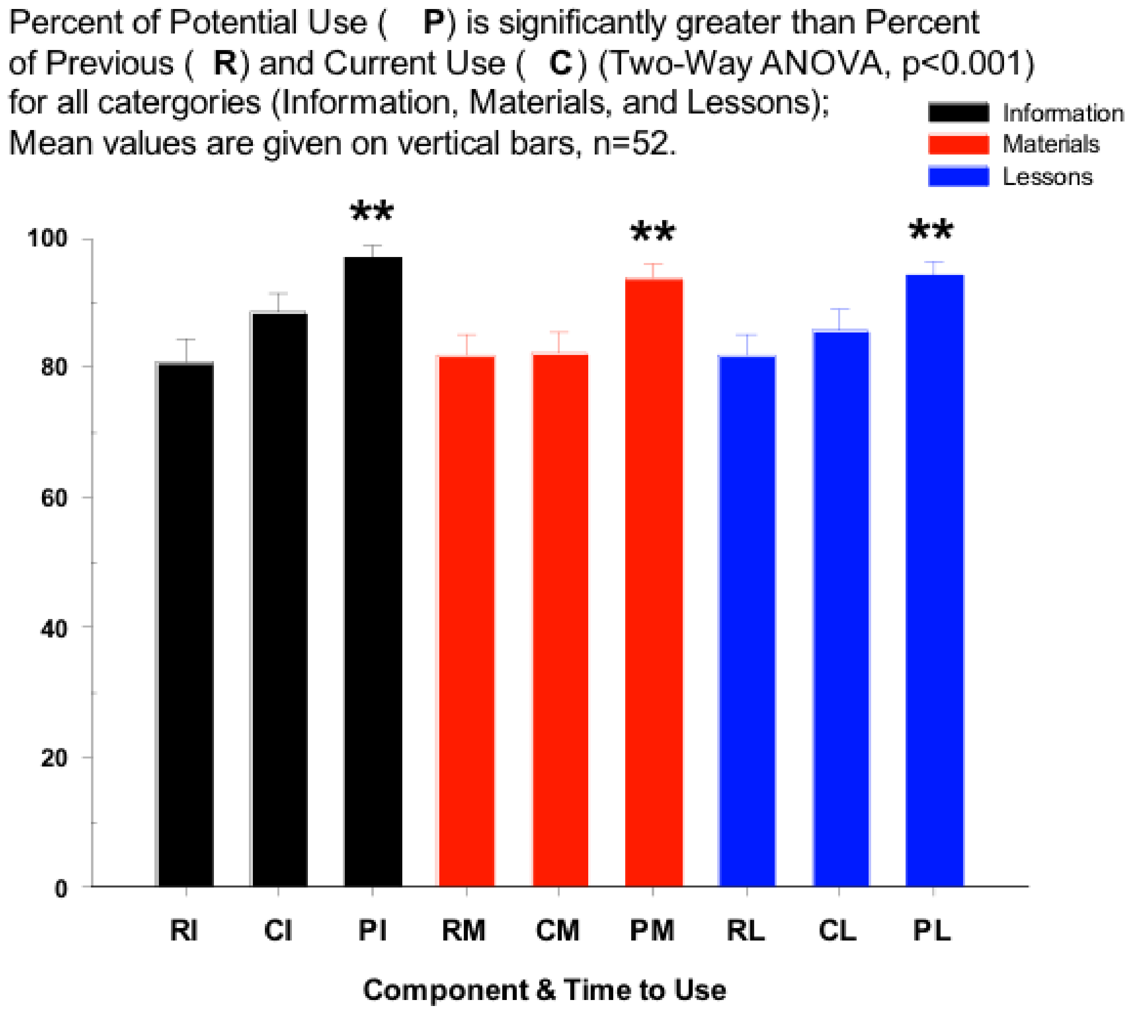

Figure 5. Transfer of Use into the Classroom

Discussion

While no statistically significant difference was found in teacher use (or potential use) between the lessons, information and/or materials, the results do point to the intertwined nature of the three. During the staff development the teachers were able to categorize these components and thus saw them as separate. When teaching the lessons they were able to see that the pieces were intertwined and thus interdependent on each other. To state the seemingly obvious, teachers who utilize the inquiry-based lessons provided in the staff development would also employ the information and materials received since the lessons themselves require the use of all components. The findings highlight the potential of this interwoven nature of the lessons, information and materials to produce a large rate of transfer into classrooms.

Consider the roadblocks to inquiry learning in the literature discussed earlier (lacking efficacy, material needs and deficit content knowledge). Efficacy itself often hinges on a teacher's content and pedagogical knowledge. In-services can provide information and materials can even be given, but staff development that incorporates both while modeling science pedagogy has powerful implications for overcoming the above roadblocks for teacher use and finally, student content mastery. The findings of this study, among others, suggest that hands-on staff development at the elementary level helps deepen teacher content mastery and therefore science teacher efficacy as evidenced by the increase in classroom use of the lessons, information and materials.

Implications for Secondary Staff Development

From an anecdotal perspective, the EEI program has tried to bring inquiry-based development to the secondary schools in Dallas with little interest, while the elementary schools book the professional developments to capacity within a week of opening the EEI calendar year. Similar kits that emphasize inquiry methods like the EEI program (i.e. Foss and Delta Scientific kits) have been utilized for years at the elementary levels by major school districts, including Dallas. Could this be the key to the national increase of elementary science scores? Conversely, could ignoring the inquiry method (or ignoring the need for inquiry pedagogical training) be a reason secondary scores are waning?

The research is clear that inquiry methods produce content mastery. So what about providing inquiry-based professional development for secondary teachers? Might their content mastery and science efficacy also rise as found here and, in turn, the scores of their students as have been seen with 5th grade scores in Texas? If the pressure is on to be successful, to pass the test, and guided inquiry is a tool found to be working in the elementary schools, what is stopping administrators from using that tool in the secondary schools?

Recommendations for Further Study

While the findings of this study demonstrate the efficacy of using guided inquiry within elementary science staff development more research should be conducted; specifically addressing the needs of high school science teachers and students. Both qualitative studies to determine factors which teacher's may perceive as impediments to their learning and using guided inquiry in the secondary classroom, as well as quantitative studies are needed. Furthermore, implementing and evaluating the effectiveness of an intervention model which uses successful elementary staff development programs (such as the one developed for EEI) as a basis for the creation of a secondary science guided inquiry staff development program is recommended.

References

Akerson, V. (2005). How do elementary teachers compensate for incomplete science content knowledge? *Research in Science Education*, 35, 245-268.

Akerson, V. L., & Flanigan, J. (2000). Preparing preservice teachers to use an inter- disciplinary approach to science and language arts instruction. *Journal of Science Teacher Education, 11*, 287-313.

Akerson, V., Hanson, D., & Cullen, T. (2007). The influence of guided inquiry and explicit instruction on K-6 teachers' views of nature of science. *Journal of Science Teacher Education,* 18, 751-772.

Banilower, E. R., Boyd, S. E., Pasley, J. D., Weiss, I. R. (2006). Lessons from a decade of mathematics and science reform: a capstone report for the local systemic change through teacher enhancement initiative. Chapel Hill, NC; Horizon Research, Inc. Retrieved from http://www.pdmathsci.net/reports/capstone.pdf.

Banilower, E.R., & Shimkus, E.S. (2004, June). *LSC professional development study: An analysis of data collected between 1997 and 2003*. Chapel Hill, N.C.: Horizon Research, Inc.

Borko, H. (1993). The integration of content and pedagogy in teaching. In A. L. Gardner & K. F. Cochran (Eds.), *Critical issues in reforming elementary teacher preparation in mathematics and science* (pp. 25-45). Greeley, CO: University of Colorado.

Clewell, B. C., Cohen, C. C., Campbell, P. B., Perlman, L., Deterding, N., Manes, S., Tsui, L., Rao, S. N. S., Branting, B., Hoey, L., Carson, R. (2004). Review of evaluation studies of mathematics and science curricula and professional development models. Washington, D.C.: The Urban Institute. Retrieved from http://www.urban.org/UploadedPDF/411149.pdf.

Correnti, R. (2007). An Empirical Investigation of Professional Development Effects on Literacy Instruction Using Daily Logs. *Educational Evaluation and Policy Analysis,* 29, 239-261.

Cuevas, P., Lee, O., Hart, J., & Deaktor, R. (2005). Improving science inquiry with elementary students of diverse backgrounds. *Journal of Research in Science Teaching*, 42(3), 337- 357.

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research, 76*(4), 607-651.

Dickinson, V. L., Burns, J., Hagen, E. R., & Locker, K. M. (1997). Becoming better primary science teachers: A description of our journey. *Journal of Science Teacher Education, 8*, 295-311.

Heck, D. J., Rosenberg, S. L., Crawford, R. A. (2006) LSC teacher questionnaire study: a longitudinal analysis of data collected between 1997 and 2006. Chapel Hill, NC: Horizon Research, Inc. Retrieved from http://www.pdmathsci.net/reports/heck_rosenberg_crawford_2006a.pdf.

Hernandez, P., Arrington, J., & Whitworth, J. (2002, January). *Professional development for elementary science teachers: Implications for practice.* Paper presented at the annual meeting of the Association for the Education of Teachers of Science, Minneapolis, MN.

Loucks–Horsley, S., Hewson, P., Love, N. and Stiles, K. E. (1998). Designing professional development for teachers of science and mathematics. Thousand Oaks, CA: Corwin Press.

Luft, J. A.(2001). Changing inquiry practices and beliefs: the impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers', International Journal of Science Education, 23(5), 517 – 534.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & et al. (2004). Inquiry-based science in the middle grades: Assessment of learning in urban systemic reform. Journal of Research in Science Teaching, 41(10), 1063-1080.

National Research Council (NRC). (2000). *Inquiry and the national science education standards: A guide for teaching and learnin*g. Center for Science, Mathematics, and Engineering Education. National Academy Press: Washington, D.C.

National Science Board. (2010) Science and engineering indicators 2010. Arlington, VA: National Science Foundation (NSB 10-01).

O'Brien, T. (1992). Science in-service workshops that work for elementary teachers. *School Science and Mathematics*, 92(8), 422-426.

Ruby, A. (2006). Improving science achievement at high-poverty urban middle schools. *Science Education, 90*(6), 1005-1027.

Smith, T. M., Desimone, L. M., Zeidner, T. L., Dunn, A. C., Bhatt, M. &Rumyantseva, N. L. (2007). Inquiry-oriented instruction in science: who teaches that way?. *Educational Evaluation and Policy Analysis,* 29, 169-199.

Stohr-Hunt, P. M. (1996). An analysis of frequency of hands-on experience and science achievement. *Journal of Research in Science Teaching*, 33, 101-109.

Texas Education Agency. (n.d.). retrieved from

http://www.tea.state.tx.us/index.aspz?id=2147484910&menu_id=660&menu_id2=795&cid=2147483660

Thompson, R. & Bolin, G. (2010). Indicators of success in STEM majors: A cohort study. Submitted to the *Journal of College Admission*, August 2010.

Valli, L. & Buese, D. (2007). The changing roles of teachers in an era of high-stakes accountability. *American Educational Research Journal*, 44, 519-558.

Wenglinsky H. (2002). How schools matter: The link between teacher classroom practices and student academic performance. *Education Policy Analysis Archives* 10(12) (February 13). Retrieved from http://epaa.asu.edu/epaa/v10n12/.

Windschitl, M. (2003) Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education*, 87(1), 112-143.

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