THE EFFECT OF TEACHER ATTITUDE, EXPERIENCE, AND BACKGROUND KNOWLEDGE ON THE USE OF INQUIRY METHOD TEACHING IN THE ELEMENTARY CLASSROOM

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By

CATHLEEN GARCIA

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ABSTRACT

Relatively recent research conducted in the area of science teaching, such as that done by Cole & Beuhner-Brent in 1991, has indicated that current elementary school science instruction is not producing the kind of science literacy desired in relation to the world's clearly greater future scientific needs. In response, professional science organizations such as the National Science Teachers Association (NSTA) are promoting the use of more activity-driven, inquiry-based instruction in the teaching of science, particularly in the elementary schools (Mastropieri & Scruggs, 1994). Inquiry-based instruction is instruction using hands-on activities that allow children to explore scientific concepts, as well as instruction in which the focus is on using process skills to gain deeper understandings of the connections in science. Studies have shown that an inquiry-based, hands-on approach is the best way to teach science in a world where facts change frequently and the difficulty of the issues faced will only increase with

time. In response to this need, many larger school districts in the U.S. have adopted new science series in which the focus is on inquiry type instruction.

Yet still, science literacy has been slow to show improvement in young children. This research was conducted to see how much of a role teacher's attitudes towards science itself, and science instruction in particular, plays in deciding to use an inquiry approach to teaching science. Surveys concerning science background, science training and instruction, and teacher attitude towards science were sent to teachers currently in elementary classrooms teaching science. Responses were compiled and analyzed, and the results were actually surprising. Read on to discover how teachers REALLY feel about teaching science in today's classrooms.

INTRODUCTION

In all education, but especially science, the teacher is the enabler, the inspiration and also the constraint. This problem is reflected in the fact that many elementary teachers, although competent and enthusiastic in most of the subjects they teach, simply do not enjoy science and do not feel comfortable teaching it (Vaidya, 1993). Yet today, we are continually reminded of the substantial gap between the current science curriculum being taught in our schools and the scientific and technological orientation needs of tomorrow's careers (Hadfield, 1993). Arguments supporting the need for better science education in elementary schools have been based on the desire to develop in today's students the knowledge, reasoning, and problem-solving skills required for the rapidly changing and technology based society (Plourde, 2002). "Today, the study of science is not only what we know, or content, but also how we come to know it, or process" (FOSS introduction, 2001, p1). Current research in the area of science education supports the notion that a hands-on inquiry-based approach to teaching science at the elementary level is a preferred method to use for developing those skills that will be necessary to handle the world's future scientific needs.

Since the elementary grades are where children receive their initial formal training in the area of science, the teachers in the elementary grades must be

prepared not only to teach but to inspire their students. Elementary school science instruction increases in importance because it is within these formative years that substantial exposure to mathematical and scientific concepts and processes is thought to be critical to later achievement in these areas. Unfortunately, there is strong evidence to suggest that many elementary teachers do not always feel science curriculum is a high priority. And when it is addressed in the classroom, it is often not taught in a way that enhances and encourages student achievement (Riggs & Enochs, 1990). According to research by Plourde (2002), less than a third of elementary teachers feel well qualified to teach science, especially when asked to use the currently-preferred inquiry approach. Perhaps this is because most, but not all, elementary teachers in the classroom today were not taught using a hands-on method while students in elementary school (Nabors, 1999), and are therefore not as comfortable with it as they are with the content-based programs that they are more familiar with from their own youth.

At a time when national reform focuses on science for all children, it is a disturbing trend to see that science is frequently taught very little in the elementary schools (Silversten, 1993), and that teaching which *is* done is accomplished primarily through lecture and textbooks rather than through exploration and experimentation. Recently William Aldridge, the Executive

Director of the National Science Teachers Association, noted that we have buried the curiosity of young children "under an avalanche of fact." (Kelble & Howard, 1994). Schools can all-too-often stifle children's natural scientific curiosity by taking the fun and natural interest out of science instruction (Jarrett, 1998). Too, when teachers avoid science during the elementary years they might be steering capable and interested students away from possible careers in the area of science, which will also be critical to the world's future needs.

The necessity for improving the way science is taught in elementary school is well documented. Science education is more than just a set of activities. Jarrett (1998) writes that there are many things a teacher needs to know in order to teach science effectively: science content, processes used by scientists, and good organizational management. Teachers need to be able to identify and remedy misconceptions, manage the operations of learning and exploration centers in their classrooms, and knowledgeably lead follow-up discussions to children's discoveries. To do this they need to acquire good questioning techniques that lead children to the answers they are seeking without simply "giving the answers".

The beliefs that teachers have about science and science instruction play a critical role in shaping their patterns of instructional behavior (Plourde, 2002). Inadequate teacher background in science, insufficient facilities and equipment,

and negative teacher attitudes about science have all been cited by elementary teachers as obstacles to effectively teaching science (Tarik, 2000). Elementary teachers in general have been found to possess a generally low level of conceptual and factual science knowledge as well as inadequate skills in the content area of science (Stevens & Wenner 1996), and general agreement exists that a lack of such background in science knowledge significantly contributes to hesitancy in teaching science and possibly to an inability to deliver effective science instruction in classroom settings.

This research study is an attempt to understand the interrelationship of self-efficacy beliefs (teachers who judge their ability to teach science low/high), attitude towards science teaching (a dislike/like for science teaching) and teaching behavior (avoidance/expressed willingness to using an inquiry approach in their science teaching) in elementary science teachers which must be understood and improved if we hope to better prepare our young children to be future science problem solvers. In this research, teachers' discomfort with hands-on teaching methods, lack of content knowledge and attitude towards science were explored. At question was the impact of these topics on teachers' use of an inquiry-method approach in the teaching of science in their classrooms. Surveys were given to teachers who are currently teaching science as a part of their curriculum in an

elementary classroom. Responses were recorded first by hand into a large chart, transferred to a spreadsheet program, and then analyzed. The results of the survey were surprising. And perhaps more questions were generated than answered.

REVIEW OF LITERATURE

Historically, the early paths of science instruction followed the philosophy of exercising student's minds through rote memorization of information. During the 1960's however, research done by Jean Piaget and Jerome Bruner, as well as others, began to change this approach of thinking about science instruction. These newly developed philosophies of learning styles and learning environments supported the assumption that "learners actively construct individual world views based on personal observations and experiences, and that learners respond to format instruction in terms of pre-existing intuitive perspectives"...(Cole & Beuhner-Brent, 1991, p.3). Piaget's research in particular recommended that positive learning environments be rich in physical experiences for children. This research indicated that *involvement in learning* was the key to intellectual development, especially during the early elementary years. Further research has also shown that science instruction needs to consist of direct physical manipulation of objects, equipment and materials to be successful (Haury & Rillero, 1994). This

"experiential learning" that occurs in elementary classrooms provides a strong base that allows for the development of abstract thinking later in life (Rillero, 1994). Using inquiry-based instruction allows children to improve their abilities to reason and provides experiences that enhance the early stages of cognitive development. Giving students direct contact with scientific investigations helps to prepare them for life in what is proving to be an increasingly complex scientific and technological world (FOSS introduction, 2001). Students are better able to understand the natural world when they work directly with natural phenomena, constructing their knowledge as they go along as opposed to experiencing it only through print material.

Despite these and earlier research findings, a majority of elementary classrooms still use a textbook-based, content-acquisition approach to science education. This is not to say, however, that these textbook-centered programs do not involve any hands-on activities, they can. However, textbook-centered science activities tend to be very directed and "cookbook" in nature. Children perform the activities more often to confirm what the text has already stated. Rarely do the activities allow students to perform an operation and derive their own hypothesis or conclusion about the materials or phenomena (Haury & Rillero, 1994). Inquiry-based programs, on the other hand, are "dynamic, depicting science as an ongoing

process of exploration and discovery, rather than a content domain to be memorized" (Mastropieri & Scruggs, 1994, p.11). Deep understanding of most science concepts comes with inquiry-oriented instruction that engages students in the investigative nature of science. Important process skills such as recording data, communicating and measuring are often seen in textbook-based programs, but the higher level process skills of predicting, inferring, hypothesizing, experimenting and identifying & controlling variables can only truly occur through activity-based experiences (Mastropieri & Scruggs, 1994).

In its essence, inquiry-oriented teaching engages students in investigations to answer questions. These questions are usually answered when students have constructed mental frameworks that adequately explain their direct experiences. Hands-on science is intrinsically fun and more interesting for students. Studies done comparing activity-based programs with comparable classrooms using a traditional or textbook approach to science indicate that dramatic differences are found in more than just the development of science process skills. Students involved in inquiry-based programs increase their creativity, have better attitudes towards science, and have improved logic development, communication skills and reading readiness (Haury & Rillero, 1994). According to Lawton, students who are exposed to an inquiry approach to science express a more positive attitude to

learning in all areas, show increased enjoyment of school, and have increased skill proficiency in many areas, including independent thinking abilities, than those students taught the traditional way (Lawton, 1997).

The question is, then, if amazing benefits can be gained from using an inquiry approach to science teaching in the elementary classroom, why isn't there more of it? Probably because teaching science using hands-on we see activities in the classroom is harder, more hectic, noisier and requires greater organizational management skills. Other worrisome barriers to implementing an inquiry-oriented approach to teaching science includes teachers' uncertainty about not only factual information but hands-on methods, discomfort with the subject of science itself, a lack of available resources and the sometimes-limited science content knowledge that many elementary level teachers seem to possess.

A review of the recent research done in the area of elementary science education that were the targets of this research found a quantity of excellent literature related to the three areas under study; comfort vs. discomfort using an inquiry-approach to teaching science in the elementary classroom, an abundance vs. lack of content knowledge in the area of science, and a basic positive vs. negative attitude towards science teaching itself.

Research done and reported in 1985 (Plourde, 2000) found that empowering elementary teachers to fulfill the daunting task of teaching science in the elementary school cannot be accomplished through hit-or-miss in-service science workshops and basic high school and college-level courses. Jarrett, in 1998, explored the relationships between the playful, fun qualities of hands-on inquiry experiences in an initial-certification science methods course and pre-service teachers' motivation to plan similar types of hands-on experiences for their classrooms. Results showed that the activities rated as fun, interesting and having a high potential for learning were the ones that the pre-service teachers indicated they would more likely implement in their own classrooms. Most of these activities were the hands-on experiences they had experienced in the initial-certification course. The activities ranked high by the pre-service teachers in Jarrett's research tended to be exploratory in nature, taught process skills in context, enabled the pre-service teachers to experience something new in a non-threatening way, and promoted social interactions (Jarrett, 1998), all of which are skills encouraged by the national science organizations today. Stevens & Wenner's research opined that ..."If the US is ever to assume a world position as first in the fields of science and mathematics, it would seem that meaningful changes need to occur in teacher education programs."

Many eminent scientists, including Nobel Prize winners Albert Einstein and Richard Feynman, reported that "scientific play" was an important part of their childhood development, and continued playfulness marked their scientific careers. Feynman, a physicist, credits his decision to "play with physics, whenever I want to, without worrying about any importance whatsoever" as leading him to the findings that won him a Nobel Prize (Feynman, 1985, p.157 cited in Jarrett, 1998). Play and science are often partners in research and invention. The fun and interest that come from playing around with phenomena can build positive attitudes toward future learning in all fields. (Stevens & Wenner, 1996, p.11).

Ginns & Watters found that teachers' beliefs and attitudes regarding the teaching of science were often firmly set prior to entry into teaching as a result of their science-related experiences in elementary and high school (Ginn & Watters, 1990). In research done by Stevens & Wenner (1996), it was noted that one might reasonably expect to find a positive relationship between higher levels of subject-matter knowledge and expressed willingness to teach science, and a negative relationship between lower level of science subject-matter knowledge and a decreased confidence in ability to teach science. The research found, however, that this was not always the case. Also discovered through research, a lack of background knowledge in science often reduces the capacity to exercise judgment

in handling the unexpected behaviors of children when using hands-on materials (Spickler & Hernandez-Azarraga, 1997). It seems clear that discomfort with science content can lead to discomfort with inquiry teaching. Teachers need to know both science content and science pedagogy to teach science well. It is not enough to have good general teaching skills when it comes to the subject of science. Good science teaching requires its own teaching strategies. As Vaidya states in her research, "...hence, teachers' science content knowledge, as well as their pedagogical content knowledge, are both issues of concerns" (Vaidya, 1993, p.63). When teachers begin to better understand science content, student learning outcomes will probably change for the better. And through in-service and retraining programs, teachers have found that they enjoy learning science using the hands-on methods and have become more comfortable with the inquiry approach itself.

Regarding teachers' attitudes towards science teaching, a survey by Tilgner (1990) showed that over half of all elementary school teachers found teaching science very threatening and ranked science at or near the bottom of subjects they preferred to teach (cited in Kelble & Howard, 1994). Interview responses analyzed by Tosun Tarik (2000) during his research on teacher attitude found that the descriptors used by his study participants to describe their feelings about

teaching science were overwhelmingly negative. Further, these negative feelings towards science negatively affected teaching self-efficacy even for those participants who had experienced earlier high achievement in science.

Hopefully, the research presented here will add even greater understandings of the correlations between teachers' comfort levels with inquiry-method teaching, teachers' science-background knowledge and teachers' attitude towards science teaching which might lead us to understandings of why science literacy levels are so low at the elementary level.

METHODS

In approaching research to this topic, it was decided that the most knowledgeable respondents would be those who were currently teaching (or supposed to be teaching) science in elementary classroom as a part of their regular daily curriculum. Surveys were sent to teachers, both male and female, from kindergarten through fourth grades in public and private institutions who teach science as a part of their curriculum. Excluded were teachers who teach only science curriculum, because it was felt that educators in those positions would automatically be more knowledgeable about science content and pedagogy, and were probably in those teaching positions because of an inclination towards teaching science. This research aimed to focus on those classrooms in which the teacher

was not only responsible for teaching science, but also responsible for the curriculum in other subject areas. Of interest was how their science teaching was affected by the three topics of this research's study; attitude towards science teaching, science content knowledge, and familiarity with hands-on methods, when there were other academic subjects of importance needing to be taught on a regular basis as well. Of particular interest was the impact of teacher experience, years teaching, and a science achievement/experience history on willingness and ability to teach science at the elementary level using the currently preferred hands-on/inquiry methods.

A "survey method" was chosen because of its' inherent ease of delivery (Gay & Airasian, 2003). The surveys were distributed to teachers at public schools and private schools in the Dallas area. Information was gathered that related to teaching experience, science background knowledge, use of hands-on/inquiry strategies in class and information on attitudes towards various aspects of science teaching. The confidential surveys included a stamped return envelope. The survey answers were coded and recorded upon return to the researcher.

The returned responses were originally hand recorded on a master spreadsheet, with "explanation" answers written word-for-word, and "Likert-type" answers coded 1 through 5. This information was then transferred to a Microsoft

Excel computer spread sheet for better and more accurate analysis of the "rated" responses. Commonalities, themes and patterns were sought in relation to inquiry-method teaching training, science background knowledge, classroom experiences and teachers' attitudes towards science in general, as well as how these may or may not affect individual teacher's comfort level with using hands-on lessons in the classroom. Analysis of the hand written responses involved breaking down the responses and categorizing them according to response versus experience, training and attitude as indicated on other portions of the survey.

One limitation encountered in this research was the access to teachers only in the Dallas area. It cannot always be assumed that the responses, attitude and training of teachers in this area would be similar to or the same as elementary teachers in other parts of the United States. As well, ideally, participants would be exposed to experimental study for a longer period of time and with a before/after format in order to more accurately assess effectiveness; however constraints on time due to college semester deadlines dictated an inability to accomplish this.

Another limitation was the way that this type of information must, by design, be gathered. Humans are fallible creatures, which lends itself to difficulties in self-reflecting, and accurate/truthful responses to questions

concerning one's own abilities and/or disabilities that might ultimately negatively reflect on themselves and their teaching style/ability. As a result the accuracy and reliability of the information may contain flaws or inaccuracies. The nature of the beast makes self-reflection difficult for many people, and thus creates difficulties for a researcher's ability to analyze responses and look for patterns in perhaps flawed responses.

A final limitation, discovered during the research, was the difficulty of getting voluntary respondents to fill out and return a survey that holds no "reward". For many, filling out information that will not impact their own lives and is not required seemed to be too much for those already busy with their own work, limiting the number of returned responses.

Forty surveys were distributed to male and female elementary level classroom teachers in public and private institutions. Fourteen surveys were returned, however one respondent didn't teach science and so the responses on that survey were eliminated. There were 12 female and one male respondents. Ten of the respondents were Caucasian, one was Asian, and two did not indicate their ethnicity. Six of the respondents had B.S, undergraduate degrees, three had B.A. degrees in areas other than education, and four had M.Ed. degrees. In addition,

two of the respondents indicated that they had graduate-level hours beyond their undergraduate degrees.

Concerning prior classes and background in science, together the respondents averaged 3.1 years of high school science courses. Two of the respondents indicated only 0 to 3 hours of college level science courses, one indicated four to nine hours of science related courses, three respondents indicated that they had had 10 to 15 hours of college level science, two reported 21 to 25 hours of science classes during their college years, and four noted that they had over 25 hours of science background classes while an undergraduate in college. One respondent wrote that she certainly didn't remember it was so long ago.

The average number of years teaching was 8.9 years, however once broken down, the experience individually showed a different picture. Seven of the surveys indicated that the teacher had only one to five years experience. Two of the respondents had five to ten years experience teaching, one respondent had 10 to 15 years experience, two had 15 to 20 years behind them, and one respondent had been teaching 26 years. Perhaps this was why she didn't remember what college science courses she had taken! The length of time the teachers with more experience had been teaching seemed to skew the average. There were more teachers at a beginning level teaching experience than the average would indicate.

For this survey, the lower elementary classes were well represented. One teacher taught K-3 classes, three taught kindergarten students only, and one taught a K-1 mixed class. Two of the teacher taught 1st grade, five of them taught 2nd grade and one taught 3rd grade classes. In these classes, eleven of the respondents taught all of the subjects to their students and two of them taught science and one other subject.

The survey instrument was a three-page questionnaire with various parts (see Appendix A). The first section concerned the teachers' level of education, years of experience, gender, ethnicity, teaching preferences (as far as subject matter is concerned), time spent teaching and preparing to teach science weekly and frequency of hands-on activities versus textbook-directed activities. The second section concerned teachers' science related background in high school and college, including any science-methods courses taken and the affect of those courses on their current teaching of science. The third and longest section involved teacher attitudes regarding science and science teaching beliefs. The strong interrelationship of beliefs, attitudes and behavior dictates the inclusion of some type of "belief" measurement in any elementary science teaching research. This "attitudes and beliefs" section allowed teachers to express a range of responses in a likert-type form, with answers to question ranging from Excellent, to Good, to

Fair, Poor and Terrible. It also included some ranking of statements that included the response possibilities of Always, Usually, Often, Sometimes and Never. Information was also collected in a "ranking" format on teachers' personal beliefs of the importance of various science related skills, as well as what barriers to effectiveness in science teaching the teachers regularly encounter. The format for the Likert-type questions was borrowed from the Science Teaching Efficacy Belief Instrument Form B. developed by Enochs and Riggs in 1990.

The respondents were told that the survey was confidential, with identifying information used only to send the results of the survey back to those respondents who requested it once completed.

RESULTS AND ANALYSIS

The information sought in this survey concerned three main areas; teachers' feelings about their background science knowledge and it's relation to their self-efficacy teaching science classes, teachers' attitude about the subject of science teaching itself, and teachers' behavior towards inquiry method usage for teaching science in their elementary classrooms.

Results indicated that eleven of the respondents felt that science was their favorite, or one of their favorite, subjects to teach. Two respondents indicated otherwise, that their favorite subject preferences were subjects other than

science. On average, 2.69 hours of science instruction were occurring weekly in the respondents' classrooms. However the differences when broken down individually by respondent showed a different picture. Five of the respondents said that only about one to 1.5 hours of science teaching a week was taking place in their classrooms. Two teachers responded that two to 2.5 hours a week was average, and two teachers wrote that three to 3.5 hours weekly was normal. On the higher end of the spectrum, two teachers taught at least 4 hours of science weekly and two teachers indicated that five hours weekly was their average. A few of the surveys indicated that science was considered a split-time class with Social Studies, either one subject or the other was taught in a week, but not both subjects. And one respondent honestly indicated that sometimes no science was taught at all.

By far the biggest difference noted in the survey was the understanding of the amount of time that was *required* for science instruction weekly. The responses indicated that there was very little agreement on this question amongst the educators. Answers ranged from four to five hours weekly to 45 minutes daily to two hours weekly and everything in between. Some of the surveys simply had a question mark beside the question. One survey response inquired, "required by the state or the principal?", one respondent noted, "… it has never been set", one survey was marked "N/A", one survey respondent honestly reported, "unsure/20

minutes a day", and a final survey response was marked "the curriculum says 30 minutes weekly for science instruction", which seems somewhat dubious. This researcher feels that this lack of clarity is clearly an issue that needs to be addressed. If teachers are not even sure how often they should be teaching science in their classrooms, it will be difficult to change the direction and styles of teaching in the less effective classrooms to begin to reach the levels of science literacy the students need before leaving elementary school behind.

The amount of preparation time needed weekly to teach science classes as reported by the survey respondents seemed to ring true. Eight of the respondents indicated that they needed one to two hours weekly to prepare to teach science in their classrooms, four teachers felt that less than one hour was adequate, and one eager beaver spent around 3 hours weekly preparing to teach their science classes.

Another area of response that showed a wide diversity of answers was the section asking about hours taught weekly using hands-on methodology versus hours taught weekly using a text-based lesson. One kindergarten teacher with a strong science background indicated five lessons weekly in both categories. However, none of the other classes even came close to this number of hours of science instruction. Of the teachers with kindergarten classes, minus the class just reported, one indicated two to three times weekly using hands-on strategies and no

text based lessons, one indicated one to two lessons weeks using inquiry method and "maybe 1" text based lesson, one indicated less than once weekly using hands on strategies and about one text-based lesson as well, and the final kindergarten respondent indicated one half-hour lesson weekly in both categories.

The primary level teachers' responses fortunately indicated that a little more science was occurring in their classrooms, but also unfortunately indicated that the emphasis was clearly not on using hands-on strategies with their science lessons. One second grade teacher reported that her science was "not often" taught using inquiry strategies, but that she did spend about four hours weekly on text-based science lessons. Another second grade teacher responded that perhaps once weekly she had inquiry lessons, but three to four times weekly she had text-based science lessons. A third 2nd grade teacher indicated that she had one to two lessons weekly using hands-on methods and three or more lessons weekly using text-book based strategies. Our male 2nd grade ESL teacher seemed to have the best "numbers". He responded that he usually had three weekly hands-on activities and one weekly text-based lesson. Perhaps because it is more difficult to teach high vocabulary textbook lessons to students with less English based vocabulary knowledge it is naturally easier to teach science using a hands-on method. One 1st grade teacher indicated that she taught science only every other week, when she

could "fit it in", but that she used hands-on and text-based lessons equally. And one 1st grade teacher indicated that two hours weekly using both types of lessons was normal for her classroom. Lastly, our 3rd grade teacher respondent said that she used hands-on lessons once a week, over a few days, and text-based lessons two times a week or more.

When questioned about how their college science classes affected their ability to teach science at the elementary level, most of the teachers indicated that that it gave them broader background/foundation knowledge to understand science, but not necessarily the ability to teach it. Three respondents indicated that their college science courses are where they developed their love for and enjoyment of teaching science. Other responses included, "definitely helped", "peaked my interest", "strengthened it to some degree" and "allows me to pull different disciplines into my teaching now". Only one respondent noted that her college science background did not help at all when it came to teaching science.

The question concerning the science methods classes required in most liberal arts teaching programs and how they might have helped the teachers teach science in their own classrooms had some very strong responses, most of them negative. Three of the teachers had not graduated with a degree in education, so they were not required to take science methods classes. Of the ten survey respondents left,

five responded that the methods classes did not help them at all in teaching science in their own classrooms. One respondent said that her methods classes did give her some new ideas of how to teach science to lower grades, and another indicated that her methods classes convinced her that hands-on learning, inquiry and experimentation were essential to understanding science concepts. However, these two respondents were definitely in the minority regarding the value of college teaching programs' science methods classes. This might perhaps also be an excellent area for further research.

A large portion of the survey centered on teachers' beliefs about their own science teaching. The questions were set up in a Likert-type format for easier answering, with answers choices including excellent, good, fair, poor, and terrible. All of the respondents indicated that they felt that their science *content knowledge* was good, and all but one ranked their *competency* for teaching elementary level science as good. Eight of the teachers ranked themselves "good" as a science teacher, four said they were "fair" science teachers, and one felt she was a "poor" science teacher. All of the teachers felt that their *students responded* either "good-7 responses" or "excellent-6 responses" to their science instruction, lending credence to the notion that even poorly taught science is better than no science instruction at all. Most teachers also felt that their

students' ability to retain science content knowledge was at least "fair" or "good" with the average response being 3.92 when 3 = fair and 4 = good. The respondents also ranked their *students' enjoyment of science* at 4.53 when 4 = good and 5 = excellent and most also indicated that they believed that their *science class was fun, interesting and had a high potential for learning* with the average response being 4.07.

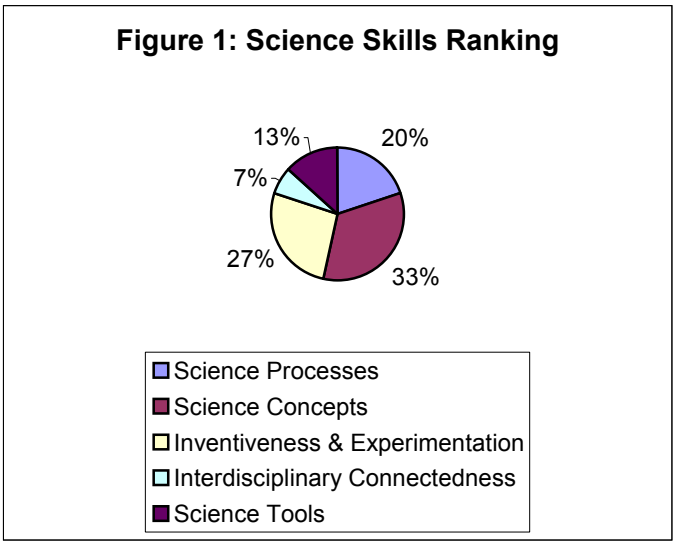
In specifically ranking their own abilities as a science teacher, all of the respondents indicated that they "usually" or "always" *teach science effectively* (average answer being 4.0 when answer choices ranged from Always, Usually, Often, Sometimes and Never), and most felt that they "usually" or "often" felt they *had the necessary skills to teach science* (3.84). Again, most of the respondents felt that they "usually" or "often" were able to *effectively monitor science experiments*, with the total being pulled down by one "Never" response for an average of 3.92. All of the teachers indicated that they "sometimes" or "never" had difficulty explaining why experiments worked.

Self-evaluations of science lesson content showed some interesting patterns. With response choices being 5=Always, 4=Usually, 3=Often, 2=Sometimes and 1=Never, the teachers felt that their science lessons often (3.15) involved exploratory learning, often (3.23) taught process skills in content, often (3.46)

allowed the kids to experience something new and usually (4.0) promoted social interaction.

The final portions of the survey requested teachers to "Rank" certain science skills in order of importance, 1 being most important and 5 being least. The answers received indicated that, at least for this group of respondents, science concepts were most important (33%), closely followed by inventiveness and experimentation (27%). Further down the list science processes ranked third (20%) and use of science tools fourth (13%). Interdisciplinary connectedness ranked last (7%). The pie chart (Figure 1) below shows the rankings of the skills according to the teacher respondents.

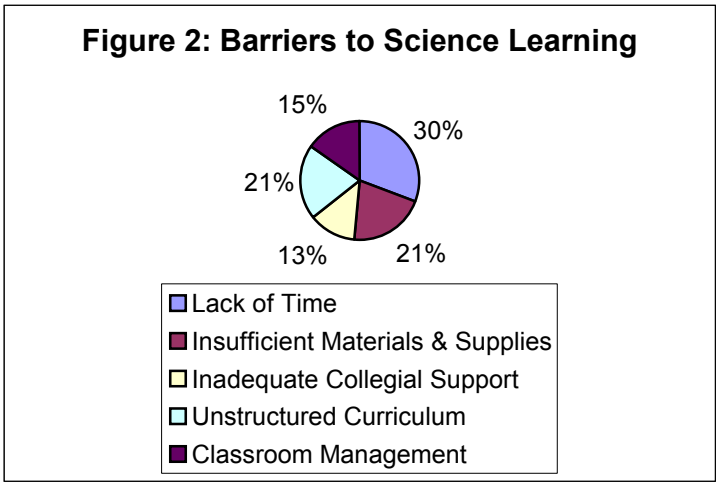
Figure 1: Science Skills Ranking



The teachers were also asked to rank "Barriers to Effective Learning" (see Figure 2) according to how often they encountered each barrier. By a large margin

"Lack of sufficient time" came in as the biggest barrier (30%). Following by a fairly large margin, second place was a tie between insufficient materials/supplies (21%) and an unstructured curriculum/resources (21%). In third place was classroom management (15%) and inadequate collegial support (13%) came in a close fourth. See the chart below for the "Barriers" results. Some individual comments mentioned the standardized testing push (TAKS) and a lack of student background knowledge as barriers to effective science teaching as well.

Figure 2: Barriers to Science Learning



CONCLUSIONS/SUGGESTIONS FOR FURTHER STUDY

The focus of science education has been on hands-on methods for some time, but the process of change is slow. Contrary to earlier research findings, this research showed that science was an interesting and well-liked subject. Most teachers feel that they're competent and have good content knowledge, yet they don't necessarily feel that they are good "science teachers". Making them good

science teachers needs to be a priority. Good science teachers will have students who respond well to science instruction, enjoy science as a subject and have the ability to retain what they are learning. If teachers feel that they can effectively teach science and have the skills they need to effectively monitor experiments, experiments that they feel they can explain, then it appears that "good" science instruction will be simply a matter of giving classroom teachers ideas and strategies that they can use to teach science using the inquiry process.

First, university-level teacher training programs need to reflect more of what the teachers will need in the classroom when they become teachers. These programs need to make pedagogical changes to their curriculum to reflect science course requirements that give pre-service teachers more background and concept development appropriate to their preferred teaching levels and more modeling of hands-on methods and strategies that they can use in their classrooms. What is needed is a restructuring of the traditional one "science methods class" currently required with most teacher training programs to include more semesters of science methods classes, perhaps at least one semester for each of the major scientific areas of study. Universities need to prepare the pre-service teachers FOR teaching elementary level science. College level astronomy courses won't teach a

fledgling instructor how to explain to their young charges about the vastness of space.

Second, there needs to be clearly set guidelines as to how much science should be occurring daily and weekly in the classrooms…more uniformity to the time spent daily in each classroom on science instruction and clearer curriculum expectations. This should also include better monitoring of the amounts and types of science instruction (textbook-based vs. inquiry method) taking place. There should be as much emphasis placed on science problem solving as is placed on Math and Reading standardized test scores at the elementary level, and this needs to be validated and encouraged by school administrators as well as science organizations.

Third, the idea of science "concepts" still holds too much weight at the elementary level. This mind frame has got to change if we expect to see major science literacy changes here in the United States. **Process skills** need to be emphasized more in the classroom. Unfortunately, "Often" teaching the skills that the NSTA recommends for good inquiry-based learning is NOT enough. There need to be more "usually" and "always" responses from elementary teachers when asked how often their lessons involved exploratory learning, process skills in context, experiencing something new and promoted social interaction. Better teacher

training, better in-service programs, and more encouragement by administrators could begin to address the issue.

As far as barriers, time is still the enemy, or LACK of time. Teachers have to be given adequate time to teach if they are to use the more-time-consuming hands-on approach. If teachers can get the science materials they need without a hassle, have it clearly explained to them what and how to teach science and be sure that they are trained to use the preferred inquiry method to teach the concepts in the process-based curriculum, then science literacy in this country will once again rise to the levels of expectation and competition in the world economy.

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APPENDIX A-Letter to Respondents

February 2003

Dear Educator,

Please allow me to introduce myself. My name is Cathleen Garcia and I teach first and second grade science at Greenhill School.

I am currently working on my Master's degree in Science Education at the University of Texas-Dallas. As part of the program, we must design a research project related to science education. I started last fall doing background research and a literary review. With that information I wrote a position paper.

This semester we must design a research instrument that helps us to gather and analyze information as to whether a hypothesis we have decided on is accurate or not. I won't go into further detail about my research question itself yet, so as not to influence your answers to the questions should you decide you can help me with the research.

What I am asking from you is that you fill out my questionnaire as truthfully as you can and return it to me in the enclosed stamped envelope by March 14th, 2003. I would really appreciate your help with my research. I won't be able to complete this class without help from my fellow teachers! The questionnaire should not take that long to fill out. I assure you that your questionnaire answers will be completely confidential, and will only be used for my research.

I will be happy to mail you a copy of the analyzed data as well as the paper itself if you would like. Just give me an address in the appropriate space on the questionnaire form. If you have any questions at all concerning my project or the questionnaire do not hesitate to call me. My home number is (972) 240-0320 and my cell number is (972) 754-9333. Please take a few moments to help me gather some information and I will forever be filled with gratitude.

Sincerely,

Cathleen Garcia

APPENDIX B-SURVEY QUESTIONNAIRRE

RESPONDENT INFORMATION

Name: Gender: M F

Ethnicity: Level of Education:

Number of years of teaching experience:

What grade levels do you currently teach?

What subjects do you currently teach?

What subjects do you *prefer* to teach?

How much time do you spend weekly *teaching* science?

How much time are you *required* to spend weekly teaching science?

How much time do you spend weekly *preparing* to teach science (include planning and material gathering)?

How often during a week do you use hands-on (inquiry-based) science activities?

How often during a week do you use textbook or trade-book based science lessons?

RESPONDENT BACKGROUND

What science-related courses did you have in high school?

What science-related courses did you have in college (include methods courses)?

How did the science-related classes that you took in high school and college affect your ability to teach science?

How did the science *methods courses* you took in college change your beliefs about teaching science?

SCIENCE TEACHING BELIEFS

How would you rank your science **content knowledge** for teaching elementary science?

Excellent Good Fair Poor Terrible

How would you rank your **competency** teaching elementary level science?

Excellent Good Fair Poor Terrible

How would you rank **yourself** as a science teacher?

Excellent Good Fair Poor Terrible

How would you rank your **student's response** to science instruction?

Excellent Good Fair Poor Terrible

How would you rank your student's **ability to retain** science content knowledge?

Excellent Good Fair Poor Terrible

How would you rank your **student's enjoyment** of learning science?

Excellent Good Fair Poor Terrible

How would you rank your **science class** on the following statement: My class is fun, interesting and has a high potential for learning?

Excellent Good Fair Poor Terrible

Rank the following statements:

I can teach science effectively:

Always Usually Often Sometimes Never

I have the necessary skills to teach science:

Always Usually Often Sometimes Never

I am able to effectively monitor science experiments:

Always Usually Often Sometimes Never

I find it difficult to explain why science experiments work:

Always Usually Often Sometimes Never

How often do your science lessons:

-involve exploratory learning…

Always Usually Often Sometimes Never

-teach process skills in context…

Always Usually Often Sometimes Never

-allow the kids to experience something new…

Always Usually Often Sometimes Never

-promote social interaction…

Always Usually Often Sometimes Never

Rank the skills below in order of importance to you, #1 being most important & #5 least important.

Science Processes……._____
Science Concepts……._____
Inventiveness & Experimentation……_____
Interdisciplinary connectedness…….._____
Use of science "tools"…….._____

Comments:

Rank these "barriers to effective science teaching" in the order of which you encounter them the most, #1 being most often encountered & #6 being least often encountered.

Lack of sufficient time……._____
Insufficient materials and supplies……_____
Inadequate collegial support…….._____
Unstructured curriculum & resources….._____
Classroom management……._____
Other (please explain)…….._____

Comments:

Thank you so much for helping me with my research project. I will be happy to send you a copy of the final paper if you will include your address below. Also, please check below your willingness to be further interviewed about your answers.

_____I am available for further interviewing if necessary

_____I am NOT available for further interviewing.

Please send me a copy of the final paper. My address is listed below: