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Teaching Science to Deaf Students: Resources for Teachers in Kindergarten to Fifth Grade

Master's Project

Submitted to the Faculty of the Master of Science Program in Secondary Education of Students who are Deaf or Hard of Hearing

National Technical Institute for the Deaf
ROCHESTER INSTITUTE OF TECHNOLOGY

by

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In Partial Fulfillment of the Requirements for the Degree of Master of Science

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Teaching Science to Deaf Students:
Resources for Teachers in Kindergarten to Fifth Grade

Abstract

Research indicates that many new teachers encounter hindrances to implementing the type of researched-based, state-of-the-art teaching methodologies for science instruction in the elementary grades, which they had learned about in their teacher preparation programs (Kane, 1994). Concerns have also been expressed about teacher preparation in the science education of deaf\(^1\) students (Lang & Propp, 1982; Lang, 1994, 1996). The present project is designed to assist new and inexperienced teachers in minimizing constraints to the implementation of an effective K-5 science curriculum, particularly in educational programs serving deaf students.

In the present paper, some of the hindrances to implementing the best practices in K-5 science are described, including five critical issues for science education presented at a national conference held in 1994 (Lang, 1994 & Egelston-Dodd, 1994). Secondly, some research-based considerations for effective teaching practices in general, in the field of science, and in the field of deaf education are presented. Finally, the results of a personal, mentored investigation of resources for new and current teachers interested in implementing research-based instructional programs in the K-5 classroom are offered as a supplementary web page to an educational web resource for teachers of both hearing and deaf students.

Importance of the Project

\(^1\) In this paper "deaf students" refers to both deaf and hard-of-hearing students.
Many factors tend to inhibit the implementation of researched-based, state-of-the-art teaching methodologies for elementary science instruction of deaf students, which aspiring teachers learn about in their teacher preparation programs (Corbett & Jensema, 1981; Kane, 1994; Lang, 1994 & 1996; & Lang & Propp, 1982). Teacher preparation programs, even with weeks of practicum experiences, are often not sufficient to ready candidates for an effective first year of teaching (Lang, 1994; NSTA, 2000). The lack of preparedness along with lack of support, poor working conditions, and student discipline problems leads over a third of all science teachers to abandon their careers between the first and ninth years of teaching (NSTA, 2000). Preparation programs for elementary teachers of both hearing and deaf students often focus primarily on language arts and math, with minimal course content in science (Lang, 1994; Lang & Propp, 1982; Corbett & Jensema, 1981; NSTA, 2000). Furthermore, many science teachers of deaf students may not have adequate knowledge of specific factors and considerations that are unique and critical for teaching deaf students effectively in any subject area, including science (Lang, 1994).

Teachers, particularly those in their first year, may not have the opportunity or time to have sufficient mentoring from experienced, skilled colleagues as to strategies that have proven successful in K-5 science instruction. All teachers face personal time constraints in their own private lives (Kane, 1994). New teachers face the added time constraints stemming from the need to create new units and lesson plans from scratch and gather the accompanying science materials for the first time. Such factors indicate a dire need for addressing these hindrances to quality education of deaf students in the field of science at the K-5 grade levels (Lang, 1994). The present project is important in addressing these concerns because it provides a detailed resource to guide teachers of elementary school deaf children in science. Such an effort has not been made previously.
**Purpose and goal**

The primary purpose of this project is to explore and share insights, strategies, and resources on how teachers can overcome some of the restraints to effective elementary science instruction of deaf students. These resources were suggested by national science education experts, fellow science teachers and professionals, experienced educators of deaf students, researchers in the fields of science and deaf education, and personnel from science centers, museums, and organizations. The primary goal for meeting that objective is the development of a supplemental web page for the Clearinghouse On Mathematics, Engineering, Technology, and Science (COMETS). The COMETS website is an information dissemination project funded by the National Science Foundation, ([http://www.rit.edu/~comets/](http://www.rit.edu/~comets/), 2001) under the direction of Dr. Harry Lang of the National Technical Institute for the Deaf, NTID, in Rochester, New York. COMETS has been successful in addressing many of the educational issues presented here, primarily at the secondary level (Lang, Mallory, & Cutcliffe, 2003). COMETS has the potential of serving as an excellent vehicle for the dissemination of supplemental information and ideas for assisting elementary teachers in overcoming typical constraints to the implementation of an effective, research based science curriculum, particularly in programs serving deaf students (Lang & Sheppard, 2004).

**Activities: Procedure and Product**

This project combines a literature review and information collected during the educational explorations of a student teacher in the development of a web resource for elementary science teachers. The literature summarizes research in three specific areas: 1) typical
restraints to the implementation of researched-based teaching practices learned in teacher
preparation programs and thus the need for assisting new teachers to overcome such restraints; 2)
research-based teaching practices specific to science instruction at the K-5 level in general, such
as the National Science Education Standards developed by the National Research Council
(1996); and 3) resources by leading professionals in deaf education detailing specific factors and
considerations critical for effectively instructing deaf students are outlined.

The findings in the literature review were combined with information and resources
gathered from educators and the science community during two student teaching experiences
required as part of the Master of Science in the Secondary Education of deaf students program at
the National Technical Institute for the Deaf in Rochester, New York. The creation of
informational web pages on the COMETS website for new teachers of deaf students in the field
of K-5 science is a final product of this project. The Elementary Science Teachers' webpage
developed for this website offers just a significant summary of the results of this project.
Included are practical ideas for countering the usual hindrances to effective science instruction of
deaf students.

Literature Review

Hindrances to the Implementation of Effective Teaching Practices

What does research reveal about typical hindrances to the implementation of the best
researched based teaching practices on the part of new teachers? While exploring the extent to
which best practices learned in pre-service teacher education are implemented by new teachers in
authentic settings, Kane (1994) identified typical constraints. She asked why many beginning
teachers have been known to “by-pass their pedagogical knowledge for less valid and less
effective alternatives” (Kane, 1994, p 9). Her research study confirmed that various time and curriculum constraints cause student teachers and first year teachers to “resort to ‘doing what comes naturally,’” with “little reference to theoretical principles” learned in their pre-service teacher education program (p. 2). Kane’s research questioned the extent to which “on-campus pre-service teacher education or “propositional knowledge” contributes to effective “practical knowledge or procedural knowledge of the beginning teacher” (Kane, 1994).

Kane conducted a longitudinal study of two randomly chosen student teachers, tracing their experiences from the time of their pre-service teacher education program through their first year of teaching. The two teachers participated in videotaping and discussions of classroom lessons through several audio taped, “stimulated recall interviews.” Additionally the two teachers kept personal journals to record their thoughts, beliefs, and ideas as they planned their lessons or reflected on their classroom experiences. The data from those sources were then analyzed.

Both student teachers had concerns about “class management, survival, and getting through the prescribed content in the time allowed” (Kane, 1994, p.5). Secondly, they engaged in strategies such as “‘knee jerk’ responses to these constraints,” adopting “teaching practices off the ‘top of their heads’ or “modeling behaviors of their supervising teachers” (p.5). Thirdly, they found it hard to see links between their university on-campus courses and their student teaching experiences. Fourthly, they saw their student teaching experience as “artificial, superficial, and of questionable value rather than as an authentic teaching and learning experience” (Kane, 1994, p.5). The student teachers felt that much of the curriculum and procedures of the cooperating classroom teachers was already in place, giving them minimal opportunities to create their own curriculum units or class management systems.
Similar results were observed during the participants' first year of teaching. The teachers continued to adopt survival strategies in order to meet the demands of the classroom instruction. They reported more time constraints during actual teaching due to planning all lessons for the first time. They had little formal support structures provided by more knowledgeable others, the participants reported reliance on “instinct, trial and error, and learning from a narrow experience base” (p.6) and responses to their students’ behavioral problems. They also reported that their student teaching experiences had little or no impact on their teaching style or ability. Finally, the teacher preparation programs were viewed as sources of “helpful technical hints rather than the theoretical basis of effective teaching and learning” (p.7).

Kane’s (1994) longitudinal study seems to verify an ongoing restraint to the implementation of the best, researched based practices that students learn about in their teacher preparation programs. New teachers seem to at times face overwhelming and conflicting influences upon their classroom practice, causing them to “adopt ‘quick fix’ survival strategies” which have little “sound pedagogical basis” (p.8).

Kane (1994) also discusses the lack of mentoring opportunities through dialogue and interaction between new teachers and experienced teachers. This lack of dialogue is also a problem in the education of deaf students. Taking an historical look at “action research,” Lang (1996) led his readers back to 1886 when Laura C. Sheridan bemoaned the lack of ‘plain talk’ about ‘practical questions’ concerning difficulties the teachers were facing in the classroom. Lang (1996) suggests that such ‘plain talk’ is still often lacking today, being superseded by formal presentations that allow little time for “open discussion” and interchanges of views and successes among teachers. Recognizing this need, as of February 2, 2004, the New York State Education Department is calling for the “completion of a mentored experience in the first year of
teaching” as part of the revised teacher certification requirements in all fields of teaching. Two purposes are “to provide support for new teachers in the classroom teaching service in order to ease the transition from teacher preparation to practice” and to increase the “retention of teachers in the public schools” (http://usny.nysed.gov/licensing/teachercertlic.html, 2004).

The National Science Teachers Association (2000) has also reported that the lack of mentoring is a serious problem on all levels of K-12 science education. These and other reports confirm the fact that new teachers commonly face many hindrances to the implementation of effective teaching practices. Time limitations and lack of experience in curriculum planning and class management seem to be the norm for new teachers, regardless of their major fields of study and instruction. The lack of sufficient opportunities for dialoguing, mentoring, and conducting personal and collaborative action research with more experienced teachers and science professionals in the community curtails one possible compensatory strategy for countering such constraints to effective science instruction.

Hindrances To Effective Science Instruction of Deaf Students: Minimal Science Preparation

Effective instruction in science at the elementary level involves more than mentoring and dialogue. Additional challenges include the lack of emphasis in elementary teacher preparation programs on science education. Many elementary teachers must begin their authentic teaching experience with a minimal knowledge of science itself. This is true both for teachers of hearing students and for teachers of deaf students.

During a presentation at a working conference on “Science for Persons with Disabilities,” Lang (1994) identified this problem as one of five, researched based recommendations for
improving science education of deaf students. Lang recommended “a comprehensive and coordinated national program...to address the science and science education preparation of K-12 teachers in school programs serving students who are deaf” (Lang, 1994). Lang pointed out that many instructors who have been trained in Deaf Education are “struggling to teach without having adequate content knowledge” in the field of science. In one study of 480 science teachers in programs for deaf children, two-thirds of which were in mainstream settings, revealed that more than 30% of those teaching science “had absolutely no college level training in science” (Lang & Propp, 1982).

**Hindrances To Effective Science Instruction of Deaf Students: Minimal Deaf Education Among Science Teachers**

While many teachers in all environments lack adequate preparation in science content, Lang (1994) suggested that many science teachers in the mainstream who are well prepared in science content “often lack training in the principles and practices of teaching students who are deaf. Importantly, there is no strong link established between science teacher preparation programs and professionals with expertise in the education of students with disabilities. Consequently, teachers being prepared in most programs are not being well informed of the resources, strategies, and materials available to assist them” (Lang, 1994, p.99). The scarcity of teacher preparation programs that teach both the principles and strategies for effective science instruction and for effective deaf education compounds the constraints to effective science instruction by teachers of deaf and hard-of-hearing students, particularly at the elementary level.
Before considering what options elementary teachers may have for developing an effective program of science instruction, in spite of these constraints, some recommended research-based teaching practices across all subjects and levels will be identified. Much research and debate has sought to discover the most effective ways to teach students in general as well as the best approach to teaching science. No complete answer or one science pedagogy, however, has emerged as the best way to teach science. Yet, even a terse survey of the research studies related to teaching and learning will reveal a number of themes or principles that have been discovered about how students learn best across all subjects, how they learn best in science, and how they learn best if they are deaf.

Effective teaching and learning principles or themes found in the literature include, but are not limited to, active learning, experiential learning, authentic problem solving, multimedia instruction, student centered learning, collaborative or cooperative learning, inquiry learning, and writing-to-learn strategies. The COMETS webpages created as part of the present project describes some researched based teaching strategies or considerations along with one or two sources of research or explanation. In the paper, only a few of these research-based teaching practices will be summarized.

One overarching emphasis presented by many educators and researchers for centuries is the notion of active learning, that is, participatory learning on the part of the student rather than passive listening, memorizing, and recording of facts and concepts. The term “hands on” has often been used to describe this type of learning and teaching strategy. However, this is not a full and accurate description of what active learning means. Astute educators and researchers have recognized that in order for learning, processing, and retention of knowledge to take place,
the mind of the learner must be actively engaged in the process, experiment, or problem-solving task at hand. Thus the term “minds on” is sometimes used to emphasize the crucial need to find ways of engaging the students’ minds in the active learning process.

Experiential learning is one of many forms of active learning, clearly incorporating both a hands-on, action component, and a minds-on, or reflection component. In discussing the education of older deaf students in science, Quinsland and Van Ginkel, (1990) suggest that “Although there are many experiential learning models, a few elements are common to all of them...some form of action, some form of reflection, and some form of application” (p.281). When the concept of experiential learning as an educational discipline first began to be considered, it took the form primarily of “environmental” or “out-of-classroom” learning” (Quinsland, 1986). Later, through the establishment of such organizations as the Association for Experiential Education in 1977 and the publishing of Journal for Experiential Learning, the definition of experiential learning was broadened and serious scholarship was undertaken. Such research has served to demonstrate how viable the experiential learning strategy is for all learners (Quinsland, 1986).

The implications of the experiential teaching model are particularly significant for deaf learners. Quinsland cites research by Boyd and George (1973) suggesting that “experiential deprivation rather than a language deficiency is responsible for a lag in abstract thinking” of deaf children.” (Quinsland, 1986, p.25). Quinsland’s own research harmonized with that conclusion. Quinsland (1986) compared learning through a traditional lecture with an experiential learning (role playing) strategy followed by ‘processing’ the information learned. Experiential treatment subjects demonstrated superior retention on a three-day delayed test of factual knowledge.
In their article, “Cognitive Processing and the Development of Concepts by Deaf Students,” Quinsland and Van Ginkel (1990) describe reflection as “the processing component” (p.281) of experiential learning models and as “the critical component” (p.281) of such a teaching strategy. Reflection is a process of considering what is important about “the action” component, which fits within the higher order thinking of the levels of mental processes described in Bloom’s taxonomy (1956), according to Quinsland and Van Ginkel (1990). They site studies showing the connection between such experiential learning and the development of “Bloom’s six levels of thought.” (Quinsland and Van Ginkel, 1990, p. 281) In general Quinsland and Van Ginkel (1990) feel that research supports the idea that the “use of experiential learning components of action and processing provide hearing-impaired students with many tools and benefits that help to mediate the effects of hearing impairment.” (Quinsland & Van Ginkel, 1990, p. 282) Additionally, when such active participation is followed by the mental process of reflection, deaf students have been found to retain “significantly more information” (p. 282) than in the active learning activity alone.

The use of technology and multimedia approaches to learning have been investigated in recent years. Lang & Steely (2003) reported on the potential for a web-based, multimedia teaching approach to enhance learning among deaf students. They summarized three studies conducted at the Oregon Center for Applied Science (ORCAS) which “support the view that there may be a beneficial synergistic learning effect obtained by the careful interspersing of text and American Sign Language explanations with animation and other graphic organizers, and by encouraging the deaf learner to interact with the materials through such techniques as the use of adjunct questions” (p. 277). The studies, including a non-web-based approach to earth science and physical science and a web-based approach to chemistry instruction, showed “that science
learning by deaf middle school and high school students can be greatly enhanced” by multimedia science programs (p.277). Lang & Steely (2003) pointed to the importance of an “underlying concept” or “big idea” approach to science instruction. “By understanding the big ideas, students are able to organize facts and concepts into a larger meaningful whole, are able to relate seemingly disparate information, and are able to use this structure of knowledge to solve problems and integrate new knowledge” (p. 286). The ORCAS programs made extensive use of sequenced presentations and reinforcement of lessons and reduction of the vocabulary load through “considerate,” short and simple texts. Those strategies, along with the use of graphic organizers, animations, and daily strategic assessment activities, were incorporated in order “to facilitate student mastery of the facts and knowledge needed to understand the big ideas” (p. 286). The use of “interactive multimedia and web-based curriculum materials yielded significantly greater knowledge gains for deaf students as compared to traditional classroom experiences” (p. 286).

The use of adjunct questions had earlier been found to improve learning from prose among deaf learners. Dowalibly & Lang (1999) studied three types of adjunct aids through a computer-based science program administered to 144 deaf students at the National Technical Institute for the Deaf in Rochester, NY. Pictorial displays in the form of content movies; sign representations through signed movies; and adjunct questions were used to discover their affects on direct learning (Dowalibly & Lang, 1999).

The purpose was to examine the effectiveness of those types of adjunct aids on direct learning (Dowalibly & Lang, 1999). To determine this the 144 students were divided into 5 groups with five different conditions and presented 11 computer-based lessons on the human eye. The first condition was the use of text only as the instructional material. A second condition
was the addition of adjunct questions. A third condition presented a content movie following the presentation of the instructional text. Condition four presented a corresponding sign movie after the instructional text. The final condition presented all of the above adjunct aids in sequence to the subjects. Within these five conditions individuals at three levels of reading ability were identified through various Reading Comprehension assessments. Among the significant results was the fact the “low Reading Level participants in the Adjunct Question and Full condition performed equal to the high Reading Level participants in the Text-Only condition” (p.278). Dowalibly & Lang (1999) attributed these results, in part, to the fact that “participants in the Adjunct Question and Full condition were required to actively engage with the instructional material by reading the adjunct question, examining the response alternative, and then selecting the one they thought was correct” (p.280), whereas participants involved in the other three instructional conditions were not required to engage in “relevant processing activities” (p.280). This is a significant finding for the education of deaf students because it suggests that the appropriate use of adjunct questions has the potential leveling “the playing field for deaf students with varying reading comprehension abilities” (p.280).

**National Science Standards**

In addition to becoming aware of the various researched based models for effective science instruction, all teachers of science would benefit by becoming familiar with the national standards for science learning, as well as their own state and local science teaching standards. An excellent source for this is *The National Science Education Standards* (NSES), which has become a guide used by many state departments of education and local school districts for the curriculum planning. The National Research Council published the *National Science Education Standards* (NSES).
Standards in 1995 through the collaborative efforts of various groups and professionals involved in science education. The NSES is based on research findings as well as the experiences and expertise of the scientific community (National Academy of Sciences, *National Science Education Standards*, 1996, and http://www.nas.edu/).

The *National Science Education Standards* details standards for teaching, professional development, assessment, programs, policies, and content at various grade levels. The teaching standards include ways to develop inquiry-based science programs; guidance and facilitation of learning; assessment of teachers; environments allowing for appropriate time, space, and resources needed for learning. They focus also on the development of communities of science learners who “reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.” (*NSES, 1996*) The suggested science content includes unifying concepts and processes, science as inquiry, understanding of various physical properties, life science organisms and environments, properties and features of earth and space, technologies, and personal and social perspectives. Teachers who desire well-informed guidance in effective teaching of science would do well to carefully read and apply the *National Science Education Standards*.

**Considerations for Teaching Deaf Students**

Lang, McKee, & Conner (1993) solicited deaf learner’s views of the characteristics of effective teachers. Teachers and administrators, in turn, were asked their assumptions of the most effective teaching characteristics. Out of a list of 32 teaching characteristics, deaf students ranked ‘uses of visual material’ second overall in their list of characteristics of effective teachers. In contrast, the faculty and administrator groups did not even have this characteristic listed as
one of their top 10 most important characteristics for teaching deaf students. Clearly, this example suggests that teachers need to become familiar with characteristics and strategies that are most effective for teaching deaf students.

Citing the findings of various research studies in their book, *Educating Deaf Students: From Research to Practice*, Marschark, Lang, & Albertini, (2002) present factors and considerations critical for effectively instructing deaf students. A few of those factors described in the COMETS webpage are summarized here. First, deaf children tend to rely on visual and spatial information more than do hearing children. For example, deaf children were found to be more likely to use a visuo-spatial coding memory than do hearing children, a strategy that aids deaf students in recalling of objects and locations (O'Connor & Hermelin, 1976). Second, deaf children tend toward a type of “cognitive narrowing” (Marschark, Lang, & Albertini, 2002, p. 83), that is, a focus on one dimension in tasks that require two-dimensional attention. (p. 83). In order to help deaf students to overcome this tendency, it is important for teachers to avoid accepting “superficial, unidimensional answers from deaf students rather than encouraging deeper” insights that are generally expected of hearing students (p.83).

Marschark, Lang, & Albertini (2002) also point out critical consideration that parents and educators often overlook, “the overwhelming amount of language learning that derives from informal interactions and activities,” (p.85) such as those encountered in classes on science, history, and literature. Thus, elementary teachers of deaf students need to be sure that they give the same attention to science related vocabulary as they do in their language-focused instruction, carefully integrating and reviewing the science related vocabulary along with the language-based vocabularies.
Additionally, a rich, linguistic and nonlinguistic learning environment provides an important foundation for learning by impacting brain development and promoting mental "flexibility and cognition," (p. 119). This points to the need for effective communication in order to promote rich social and educational interactions. “Students with positive social interactions in school tend to have higher academic achievement, better mental health, and are more likely to succeed in their careers” (p.83). Elementary and secondary teachers across all subjects need to provide effective communication and opportunities for social interaction for deaf students. “The intertwining of language, social, and cognitive development is fundamental to deaf children’s construction of knowledge about the world...nurturing these developmental domains in home, school, and community activities must be one of the highest priorities” (p.85) for deaf students. It is important for teachers of elementary science to become knowledgeable about critical factors in the educating of their deaf students and to be mindful of such factors when constructing their science curriculum, environments, and strategies.

**Exploring Effective and Efficient Strategies and Resources**

Assuredly, becoming familiar with the most current research on teaching science and teaching deaf students is both beneficial and essential for elementary teachers of science. However, no one methodology has emerged as the best way to teach science to hearing or deaf children, nor have any easy answers arisen as to how to help teachers overcome the various constraints to the development of an effective teaching curriculum and methodology. Such a state of affairs seems to put Lang’s (1996, p.280) suggestion of “the teacher as researcher” high on the list of the most viable, time effective, and cost-effective ways to guide teachers.
utilizing science outreach programs available in local areas. Also, tips for exploring funds, programs, and materials available through science organization; seeking the ideas of fellow teachers, professionals, and students; and learning what research says about teaching science are included. The full text of the webpages for elementary teachers of science is recorded in the Appendix of this paper.

With regard to the exploration of outreach programs through museums, universities, and science centers, it is of interest to note that the NSES recommends that science teachers identify and use resources outside the classroom by consulting with science specialists in the community, such as are found at science centers and museums, colleges, and industry. (NSES, 1996) Through communication with the science educators of local museums, universities, and science centers in the Rochester, New York area, a wealth of information, programs, ideas, and resources was discovered. K-12 science teachers in many school districts have taken advantage of the expertise and resources of such members of the scientific community to enhance their teaching, while minimizing the time spent in searching for lesson ideas and materials. Only a small sampling of such discoveries could be included in this project and on the COMETS website. Yet the depth of ideas, materials, and support available to teachers through the expertise and resources of the scientific community is evident through those samplings.

Conclusion:

Often, as is the case in many fields of endeavor, teaching elementary science is a matter of on-the-job training. Add the critical considerations necessary to teach deaf students effectively and the challenge escalates. For many students currently in teacher preparation programs, the challenge will be "trial by fire." As a first step in helping to make this challenge less overwhelming for new elementary teachers of deaf students, this project has provided a list of
Lang (1996) indicates that the incorporation of discourse among teachers, researchers, and others in the teaching communities of our schools could enable teachers to become their own action researchers, collaboratively "arriving at best practices" (p. 280). This would include interactive, systematic, and insightful reflection on each other's teaching experiences. In his description of what such "action research" actually is, Lang relates examples from back in the nineteenth century. He gives an example of a collaborative, teacher and administrator, "hands-on" classroom teaching experiment to explore the best ways to engage deaf students in the thought processes of mathematics (p. 279) and of group discussions about "correct methods of teaching" (Lang, 1996 p. 280) by teachers of deaf students. Bringing the concept of action research and community discourse back into our day, Lang suggests that we need find ways to "empower teachers as action researchers," (Lang, 1996, p. 280) in systematically investigating hunches and sharing successful experiences to arrive at effective teaching and student achievement.

Whether through the process of being one's own action researcher in collaboration with others in the field of science and deaf education or my another means, each new elementary teacher will need to explore effective and efficient strategies and resources for teaching science. In the case of those serving deaf students that exploration will need to include further exploration of effective and efficient strategies and resources for teaching the deaf child. The final part of this master's project, the addition to the COMETS website, is the result of such explorations on the part this future teacher of deaf students. The information includes only a small sampling of what was learned through that exploration undertaken primarily during 18 weeks of student teaching, as part to the teacher preparation program at NTID.

The webpages include ideas for becoming familiar with the national, state, and local science standards; learning specific considerations in educating deaf students; and exploring and
critical resources to help such new professionals learn about issues and directions recommended by experts in the field. In this regard, the concept of the teacher as an action researcher is a viable strategy. Whether new or experienced, ongoing experimentation with one’s teaching and curriculum development efforts will help us enhance learning by deaf students. Mentor-ship arrangements with experienced teachers will facilitate this process further.

Ten years ago leading researcher and teacher in deaf education, Dr. Harry Lang, “effectively set out to build a national agenda for the science education for deaf students” (Egelston-Dodd, 1994, p.110) when he identified five critical issues and recommendations for science education at the working conference on science education for students with disabilities. Those issues and recommendations warrant further examination as they still address current needs for science education in general and for science education programs for the deaf.

Lang’s (1994) first recommendation focused on the teacher preparation programs in science and science education for future teachers of deaf students. Considering the minimal preparation in the area of science that elementary teachers and teachers of deaf students often receive, enhancing teacher preparation programs seems to be a good place to start in order to provide teachers with the foundation they need in both science education and deaf education. So the recommendation for the development of a “comprehensive and coordinated national program…to address the science and science education preparation of K-12 teachers in school programs serving students who are deaf,’ (Lang, 1994, p. 99) warrants further investigation and effort.

A second recommendation relates to support for K-12 teachers and for teacher training programs designed to improve science education for deaf students. Lang (1994) called for the establishment of a national networking program for science teachers of deaf students to
“coordinate efforts to develop, disseminate, and evaluate science instructional manuals” (p. 103). This would include materials modified for deaf students in such areas as appropriate English language levels, career education infusion, communication skill development, and multi-sensory and hands-on experiences, all designed by teachers and packaged in a versatile and inexpensive manner. This he set out to do himself with a National Science Foundation grant (Lang & Sheppard, 2004) that led to the creation of the COMETS web resource. The present project focusing on elementary science education has added a new dimension to that resource for elementary science teachers. Additionally, The Deaf Net, (http://www.deaf.net/), a national communication resource, has been established to provide a wide range of information and resources for parents and educators of deaf children.

The third recommendation was an appeal to members of the scientific community to take the lead in establishing such a national networking system for the support, direction, and improvement of teacher preparation programs for deaf and disabled students. Lang (1994) called for national science organizations to take the “leadership role in planning and coordinating the enhancement of science teacher preparation and instructional materials development and dissemination for use of programs serving students who are deaf.” Since neither school teachers and supervisors, nor professional organizations for educators of deaf students, would be able to take the leadership role in such a bold step in the near future, the former group due to time constraints and the latter group due to “struggling for survival and direction,” a collaboration between scientific societies and universities involved in deaf education would be probably be necessary. (p. 104) Such a collaborative effort has the potential to “provide better education and further accessibility for people with disabilities in science in the future” (p. 105)
Another collaboration was recommended among professionals in special education. Lang proposed that professionals in science education for students with disabilities should collaborate in sharing resources and expertise. Finally, Lang (1994) recommended that "educators in the field of teaching science need to become an integral part of the planning, developing, and evaluating teams involved in the national science education efforts," such as those by the National Research Council in "establishing new standards and directions for science education in the United States" (p.106).

Could a national network among those responsible for science preparation programs of teachers serving deaf students prove helpful in increasing the percentage of teachers adequately trained in both science education and deaf education? Would a national network of science teachers of deaf students enhance the preparedness and support of such teachers? Would further assistance, resources, and direction become available to such teachers through the involvement and leadership of members of the nations scientific societies and organizations? Could further support be provided by a collaboration of efforts, strategies, and resources among those involved in special education throughout the country? Could the involvement of science educators of deaf and disabled students in the planning and evaluating of the national science standards provide insights that would enhance the teaching of science to deaf students? What others recommendations can made to lessen the constraints to effective science instruction of deaf students in the elementary grades and to generally improve the quality of science education for deaf students?

These are questions that have been examined by the National Science Foundation grant COMETS, but they require further examination and study over time. Teachers of deaf students interested in discovering time and cost effective ways to enhance their teaching of science should
tap the resources in COMETS, as well as those available through other networks of experienced teachers (such as Deafed.Net), members of the scientific community, and their own students.

Transforming one's own teaching through ongoing action research by applying principles of scientific inquiry to explore the most effective and meaningful ways to facilitate the learning of science concepts, skills, and processes by deaf learners, could reap great rewards in teacher and learner satisfaction.
Appendix A

This information for “Exploring Effective and Efficient Strategies and Resources” is posted on the COMETS website within the “K-12 Teachers” webpages of COMETS, under the topic, Elementary Science Curriculum Development Tips.

Product: COMETS webpages

Teaching Elementary Science to Deaf and Hard-of-Hearing Students

Often, elementary science teachers are asked to develop a curriculum for the early grades and to teach science and mathematics to deaf students. More often, these teachers do not have the training to begin such a task and are desperate for assistance. This webpage is being developed to provide such assistance.

Exploring Effective and Efficient Strategies and Resources

Topics:

What hinders researched based science instruction?

How can teachers find sources of materials, ideas, and strategies?

Becoming familiar with the national, state, and local science standards

Learning special considerations in educating deaf and hard of hearing students

Exploring and utilizing science outreach programs available in local areas

Exploring funds, programs, and materials available through science organizations

Seeking ideas from fellow teachers, professionals, and students
Learning what research says about teaching science

*What hinders researched based science instruction?*

Though most new elementary classroom teachers are eager to implement the best researched-based practices in science instruction they often encounter obstacles. For teachers of deaf and hard-of-hearing students, additional factors can make the implementation state-of-the-art teaching methodologies for science instruction at the elementary grade level even more challenging.

**Why?**

Teacher preparation programs for elementary teachers often focus mostly on language arts and math, with minimal course content in science.

- State requirements for science instruction are often minimal, particularly at the K-3 level.
- Knowledge of specific factors and considerations unique and critical for teaching deaf and hard of hearing students effectively in any subject area is often lacking.
- New teachers may not have the opportunity or time to have sufficient mentoring from experienced and skilled teachers as to successful strategies in K-5 science instruction.
- Time constraints, particularly for new teachers who must gather ideas and materials for preparing new curriculum and lesson plans from scratch, hinder effective teaching.

The list above includes just a few of the hindrances to quality education of deaf and hard-of-hearing students in the field of science at the K-5 grade levels.
How can teachers find sources of materials, ideas, and strategies?

Becoming familiar with national, state, and local science standards

National Science Education Standards

Source: National Science Education Standard (NSES) and electronic version:
http://www.nap.edu/readingroom/books/nses/html/

National Science Education Standards are criteria used to judge the quality of the knowledge and abilities of students; of the programs and instruction; of the support systems for teachers and programs, and of the assessment practices and policies in science at the state and local levels. (National Science Education Standard, NSES p. 12)

The National Science Education Standards were developed and revised by the National Research Council and many other individuals and groups, such as “administrators, parents, curriculum developers, college faculty and administrators, scientists, engineers, and governments officials,” (NSES p. 3) for the purpose of meeting the goal that “all students should achieve scientific literacy .... in the 21st Century.” (NSES, p. ix)

Purpose of the National Science Education Standards:

(National Science Education Standard, NSES pp. ix-3:12)

- Provide a means to assess “progress toward a national vision of learning and teaching science in a system that promotes excellence.”
• Provide criteria to help state and local personnel and communities to judge appropriate curriculum, staff development, and assessment policies.
• Emphasize teaching and learning that reflects how true science is approached.
• Make “science courses relative to students’ lives.”
• Promote the best practices of extraordinary teachers and provide them support and recognition.
• Give direction for establishing the best education in science in the future by building on the current best practices and lessening current structural constraints to best practices.

Specific Standards have been developed in the following areas:
• Science Content
• Professional Teacher Development
• Assessment in Science Education
• Science Teaching
• Science Education Programs
• Science Education Systems

Each of these emphases is explained with excellent examples in the NSES standards. Of the above six emphases this web page focuses on Science Content and Science Teaching. It is highly recommend that teachers read the NSES materials to develop a thorough understanding of these general suggestions for instruction.

What Science Should We Teach?
Science Content

The National Science Education Standards provide the following recommendations or guidelines for science content. State departments of education tend to use those national standards to guide their frameworks for curriculum content. Then, each local school district decides how and when it will implement the state science standards.

The national science standards and, therefore, most state standards tend to be well-grounded in researched based, state-of-the-art teaching strategies. The state science assessments also tend to follow the national standards and researched-based types of assessments. Many states' tests include performance assessments along with the usual written type of assessments. In general, school districts and individual teachers tend to guide their curriculum content, instructional methods, and types of assessment by the national and state science standards.

Becoming familiar with and incorporating all three levels of science standards in the classroom science curriculum may greatly enhance a teacher's effectiveness and efficiency in developing unit plans and lessons that are well grounded in research within national, state, and local expectations. Below is a sampling of some of the national science standards. For a complete and detailed description of the national science standards, check the National Science Education Standard, or the NSES web site: http://www.nap.edu/readingroom/books/nses/html/

Rationale for the National Standards

(National Science Education Standard, NSES pp. 104)
• Unifying Concepts and Processes:

• Science as Inquiry – Content Standard A
• Physical science - B
• Life science - C
• Earth and space science - D
• Science and technology - E
• Science in personal and social perspectives - F
• History and nature of science - G

Unifying Concepts and Processes: K-12

(National Science Education Standard, NSES pp. 115-119)

The NSES recommends that activities should develop in students understanding and abilities related to the following concepts and processes.

• Systems, order, and organization

Systems: Investigating and analyzing smaller units (systems) of our world
Order: Predicting and statistically describing “the behavior of units of matter, objects, organisms, or events in the universe.” (NSES, pp. 116,117)

Organization: Organizing data about complex and varying systems

- Evidence, models, and explanation

Evidence: Using observations and data as basis for scientific explanations

Models: Using models of objects and events to understand how things work

Explanation: Using current knowledge, evidence, and scientific terminology to form rich, logical scientific explanations.

- Constancy, Change, and Measurement

Constancy: Recognizing the properties and processes that are unchanging.

Change: Recognizing the types, causes and variations of changing factors
Measurements: Using the appropriate systems of measurement for the appropriate purposes

- Evolution and Equilibrium

Evolution: Recognizing and describing evolutionary processes in the universe

Equilibrium: Understanding the physical state in which forces and changes that are occurring in opposite and off-setting directions tend to move toward equal, balanced, and steady states.

- Form and Function

Form and Function: Being able to explain the function of objects, organisms, and systems by referring to their form and vice versa.

Science Content

Science Content Standards A Through F
(NSES Outline of content standards criteria: K-4 p. 109; grades 5-8 p. 110; & grades 9-12 p.111)
Again, the following emphases are explained with excellent examples in the NSES standards. Developing a thorough understanding of these general suggestions for instruction is highly recommended.

**Science as Inquiry: K-4**

**Content Standard A**


Note: This “inquiry” form of active learning is a critical emphasis of the NSES and of science education research.

The NSES recommends that inquiry activities develop in students the following.

- **Abilities necessary to do scientific inquiry**

  *(National Science Education Standard, NSES pp. 122, 123)*

  **Ask about:** Objects, organisms, and events in the environment

  **Plan and conduct a:** Simple Investigation

  **Employ equipment and tools to:** Collect data and extend the sense

  **Use data to:** Construct a reasonable explanation

  **Communicate:** Investigations and Explanations
• Understanding about scientific inquiry or scientific investigation

( *NSES* p., 123)

**Definition:** Asking, answering, and comparing own questions about the world to known scientific knowledge about the world

**Types of Scientific Investigation:**

**Describing:** Objects, events, and organisms

**Classifying:** Objects, events, and organisms

**Experimenting:** Testing fairly

**Obtaining Information:** Use of instruments such as magnifiers, thermometers, and rulers, provides more information than use of senses alone

**Developing explanations:** Based on evidence obtained from observations and on prior scientific knowledge

**Publishing results:** For public knowledge and possible repetition of the investigation
Reviewing and inquiring: About results of the work of other scientists

Note: COMETS has a sample lesson, “Earthworms,” K-4 Life Science Content, utilizing inquiry and additional standards.

Physical Science: K-4

Content Standard B

( *NSES* pp. 106 & 123-127. See grades 5-8, pp. 143-155 & 9-12, pp 176-181)

The *NSES* recommends that activities should develop the following understandings in K-4 students:

- Properties of objects and materials
- Position and motion of objects
- Light, heat, electricity, and magnetism

Life Science: K-4

Content Standard C
The NSES recommends that activities should develop the following understandings in K-4 students:

- The characteristics of organisms
- Life Cycles of organisms
- Organisms and environments

Note: COMETS has a sample lesson, “Olympiad” K-4 Life Science Content, utilizing assessment and additional standards in evaluating student performance

Earth and Space Science: K-4

Content Standard D

The NSES recommends that activities should develop the following understandings in K-4 students:

- Properties of earth materials
Objects in the sky

Changes in earth and sky

Science and Technology: K-4

Content Standard E


Activities should develop in K-4 students the following:

- Abilities of technological design
- Understanding about science and technology
- Abilities to distinguish between natural objects and objects made by humans

Science in Personal and Social Perspectives: K-4

Content Standard F

(NSES pp 108 & 138-141. See grades 5-8, pp. 166-170 & 9-12, pp 193-199)
The *NSES* recommends that activities should develop in K-4 students understanding of the following:

- Personal and community health

- Population growth

- Natural resources

- Environmental quality

- Natural and human-induced hazards

- Science and technology in local, national, and global challenges

**History and Natural Science: K-4**

**Content Standard G**

(*NSES* pp 108 & 141. See grades 5-8, pp. 170, 171 & 9-12, pp 200,201)
The \textit{NSES} recommends that activities should develop in K-4 students understanding of the following:

- **Science as a human endeavor**

- **Historicity** - science and technology has been practiced for a long time

- **Contributions** – have been a great variety of scientific contributions by men and women

- **Never-ending** – always more objects, events, and phenomenon to study and understand

- **Satisfaction** – many people enjoy careers or devote lifetimes in the study of science

\textbf{How Should We Teach Science?}

\textbf{The NSES teaching standards encourage teachers to:}

\textit{(National Science Education Standard, NSES p.28)}

- Create an environment in which students participate as active learners about the natural world and scientific principles.
• Work with colleagues to expand theoretical and practical knowledge of science and of teaching strategies

Science Teaching Standards A Through F

(NSES Outline of teaching criteria, grades K-12, pp. 30-52)

Plan inquiry-based science program for students

Teaching Standard A

• **Develop framework for yearlong and short goals** – remain flexible – consider experiences and interests of students – address topics from student inquiry - current and community events

• **Select science content** – adapt curriculum to students’ interests, knowledge, understanding, abilities, culture, and experiences – consider local environmental study opportunities – coordinate with local science center personnel - universities, industry, museums

• **Select teaching and assessment strategies** – supporting development of students’ and nurturing a community of learners - understanding, abilities, and experiences

• **Central strategy** – inquiry into authentic student questions
• **Focus on real phenomenon** – teacher or student generated investigations – in classroom, outdoors, or laboratories within students’ capabilities

• **Inquiry approach** – guide students to acquire and interpret information from multiple sources – libraries, government documents, computer databases - experts in industry, community, and government – teachers, texts, videos, film, and computer simulations

• **Focus on processes** - for acquiring knowledge – finding authoritative, acceptable sources

• **Collaborative teaching** – guided sharing and debating of ideas related to scientific concepts and the nature of scientific endeavor

• **Decide appropriate group size** – based on purpose - whole-class, small-group, or individual exploration – e.g. investigating electric circuits, perhaps individually

• **Strategic planning** – consider diverse interests, abilities, and cultural backgrounds of students – sensitivity to student views that conflict with scientific knowledge and strategies – support alternative ways of making sense of the world
• **Assessments and monitoring activities** – designed to monitor and assess the progressive development of the students' scientific knowledge, understanding, and abilities

• **Work collaboratively with colleagues** – seek time and access to fellow teachers for collaborative planning – through school administrators - across disciplines and grade levels

**Guide and facilitate learning**

Implementing the Standard A plans

**Teaching Standard B**

• **Guide, focus, challenge, and encourage student learning** - to promote inquiry and understanding through their own examinations, explanations, clarifications, and assessments

• **Orchestrated oral and written discourse** – in many forms relating the learning process and connecting scientific concepts to larger domains

• **Encourage students to share responsibility for their own learning** – designing and carrying out their own investigations – cooperating with group members
• Respond to student diversity - insure equal participation – modify for special needs

• Model characteristics of a scientist – enthusiasm, inquiry, curiosity, openness to new ideas, scientific skepticism, and good judgment – develop through interfacing with colleagues

Engage in ongoing assessment of own teaching and of student learning

Collecting data for instructional decisions and communication about student progress

Teaching Standard C

• Systematically gather data about student performance and understanding – using multiple informal and formal methods – appropriate to purpose

• Analyze assessment data - to guide instruction and build learning activities from current student understanding, experience, and culture

• Facilitate student self-assessment strategies – through increased understanding of the purpose of their own learning
- **Self-reflection and improvement of personal teaching practice** – through student data, observations of own teaching, interactions with colleagues, and discussion of research

- **Report student achievement** – not just grades - to the necessary individuals and agencies

**Design and manage learning environments**

Collaborating with school administrators, community members, students, and parents

To provide time, resources, space and funds for effective science learning

**Teaching Standard D**

- **Structure time for extended investigative engagement** – restructure schedules to allow exploration, interdisciplinary strategies, and field experiences for scientific investigation

- **Create flexible setting for scientific inquiry** – arrangement of space and furnishing in the classroom or laboratory allowing for work in progress and display of results

- **Ensure a safe work environment** – learn, apply, and teach necessary safety regulations for use, storage, and care of materials and for safe scientific experiments indoors and outdoors
- **Make science technology, media, tools, and materials accessible** - select appropriate materials and guide students in accessing scientific information

- **Identify and use resources outside the classroom** – specialists in community, science centers and museums, colleges, and industry – environment in and around school used as a living laboratory

- **Engage students in design and management of the learning environment** – student participate in discussions and decisions about the use and care of space and resources

**Develop communities of science learners**

Reflect the rigor of scientific inquiry and the attitudes and social values conducive to science learning

**Teaching Standard E**

- **Display and demand respect for diversity of ideas, skills, and experiences of all students** – through words, actions, and responsive flexibility in and modification of activities to reflect interests, ideas, strengths and needs of students
Give students a voice and responsibility - in decisions about the content and context of their work and the learning of all members of the community

Nurture collaboration among students – to enhance learning and practice the skills, attitudes, and values characteristic of science

Structure and facilitate formal and informal discussions – ongoing in nature - based on a shared understanding of the rules of scientific

Model and emphasize the skills, attitudes, and values of scientific inquiry – such as wonder, curiosity, and respect of nature

Participate in ongoing planning & development of the school science program

Be active as members of a larger science learning community

Teaching Standard F

Plan and develop school science program – support the collaboration of the entire school staff with resources in the community for planning, designing, and implementing new teaching practices in science
Participate in decisions about the school science program – concerning allotment of time and resources

Participate in planning and implementing professional growth strategies – for self and colleagues

For more on the "How" (strategies of teaching), sample science lessons for various grade levels can be viewed on the COMETS website. After clicking "Welcome/Enter" find and click on "K-12 Teachers" along the left/vertical column. Once on the "K-12 Teachers" web page, click on "Lesson Plans" in the table of contents.

On that same "K-12 Teachers" web page and table of contents workshops, under "Teaching Emphases," are posted that are designed to expand teachers' theoretical and practical knowledge of effective teaching practices and there is a COMETS Discussion Board encouraging interaction among colleagues both within schools and across the nation.

State Science Education Standards

Each state has its own objectives, standards, and priorities. Most states use the national standards for both science and mathematics as a basic guideline, but may have certain, specific ideas, or preferences for how to implement those standards. Many states have their standards described both in hard copy form and on the internet via websites.

Two reliable and extensive sources for familiarizing oneself with the state standards and/or general curriculum policies of the state boards of education are listed here. One is the
Eisenhower National Clearinghouse for Science and Mathematics Education, (ENC), authorized by the Excellence in Mathematics, Science, and Engineering Act of 1990. The ENC includes information about national frameworks and standards for both science and mathematics. It also provides extensive information, resources, materials and samples of curriculum ideas, lesson plans, and teaching strategies for all those in the field of deaf education.

To explore this extensive resource write to Eisenhower National Clearinghouse, The Ohio State University, 1029 Kenny Road, Columbus, OH 43210-1079; phone at 614-292-7784; Fax to 614-292-2066; email ENC at info@enc.org or explore their website, particularly under the topic heading of “Professional Development” at: http://enc.org

All state departments of education can be found at the following website: http://www.teacher.com/sdoe.htm by clicking on the state shown on a US map. Those sites include extensive details about the particular state’s learning standards in all subject areas and generally point to curriculum ideas and resources for schools and teachers.

Local Science Education Standards

To obtain local or individual school standards, educators will need to check with the individual school district administrators such as the superintendents or principals of those schools of interest.

Learning specific considerations for educating deaf students

Although the NSES addresses the importance of teaching science to "all students," the developers of the standards did not have the resources or charge to recommend specific strategies for deaf children. In order to familiarize oneself with research about deaf learners, an educator
or deaf students will need to look to published research journals in their college or university libraries, as well as searching the internet.

This section of the COMETS website will help elementary science teachers identify needs of deaf learners, in particular, and key emphases on which teachers should focus to best prepare deaf children for continued and effective science learning in subsequent grades.


**Some General Considerations for Teaching Deaf Students**

- Language environment and language accessibility in the first few months of life is crucial for children.

- Deaf children without early exposure to language are at a disadvantage requiring needed remediation. p. 80, par. 2 & 3.

- Studies show that “hearing mothers tend to be controlling and directive in interactions with their deaf children, behavior that...deprives children of important trial-and-error learning experiences.” p.81, par. 1.
• Parents who provide effective communication through a combination of sign and speech have less need for protective, intrusive control over their deaf children. p. 81 pars. 1 & 2

• “Students with positive social interactions in school tend to have higher academic achievement, better mental health, and are more likely to succeed in their careers.” p.83, par. 1

• Deaf children tend to have less essential experiences for acquiring knowledge, including less variability of exploration and interaction with the people, things and language in the environment than do hearing children. p. 83, pars. 1-3.

• Deaf children tend to rely on visual and spatial information more than do hearing children.

• Deaf children are more likely to use a visuo-spatial coding memory than do hearing children, a “strategy that enhances recall of things and locations”. p. 83, par. 3

• Deaf children tend toward a type of “cognitive narrowing,” that is, a focus on one dimension in tasks that require two dimensional attention, p. 83, par. 3

• Teachers need to avoid accepting “superficial, unidimensional answers from deaf students rather than encouraging deeper” insights that are expected of hearing students. p.83, par. 3
• Educators need to recognize and make full use of the primary sources of extensive language and vocabulary development that come from informal interactions in non-language-focused classes such as science, history and literature. p. 85, par. 2

• "Early experience with sign language might be expected to have positive effects on spoken language development, regardless of hearing status." p. 106, par. 1

• "Evidence shows that the richness of the environment has a direct impact on brain development" and therefore on mental "flexibility and cognition." p. 119, par. 1

• Therefore "a diverse linguistic and nonlinguistic environment provides an important foundation for learning." p. 119, par. 1

• With regard to memory strategies, one modality of language does not have the advantage over another one, but working memory "seems to function best with speech-based memory codes...for both deaf and hearing students." p. 120, par. 3

• Deaf students may have different knowledge bases, cognitive strategies, and experiences" than hearing students. p 134, par. 2

• Therefore "deaf children should not be taught as though they were hearing children who cannot hear," but should be given activities and experiences which take into consideration such differences. p. 134, par. 2 & 3
Some Strategies and Activities Suggested for Teaching Deaf Students

- Using **concept maps** to expand discussion of vocabulary to semantic fields or networks. p. 134, par. 3
- Use **word games** to discuss and encourage multi-meaning of words. p. 134, par. 3
- Use and encourage **problem-solving games, creative language, fantasy, and imagination** to promote flexible cognitive functioning. p. 134, par. 3
- In reading programs, have children do **story telling** presented in signed and spoken language p. 184, par. 2
- Encourage children to **re-tell, act out, and collect or draw pictures** related to stories “to establish links between the written word, meaning and the language used in one-on-one communication.” p. 184, par. 3
- Implement reading **strategies** used by **deaf adults** with their children. p. 184, par. 2

*Exploring science outreach programs available in local areas*
• Local museums, science centers, and colleges - phone to inquire about outreach science education programs for schools and teachers

• Program directors - meet with them in person to learn more – see facilities and materials

• Free resources - inquire about free materials, outreach programs, and informational booklets

• Funding - inquire about grants or other potential funding for schools and teachers

• Inform - school administrators of outreach programs and resources

• Propose – that school administrators take advantage of such programs and resources

What ideas, materials, and educational programs might be found?

• In-service teacher training programs – workshops - weekend or summer

• In-school programs - science lessons taught by college, museum, or science center personnel
  – on one time or regular basis – school year or summer

• Science kits or materials – relating to national and state standard unit plans – free or purchased with state aid assistance – borrowed or rented – stored and refurbished outside the school
• Community service opportunities – student involvement in authentic, volunteer science projects – with in-class instructional and equipment assistance – usually free

• On-site science programs – opportunities for student and teacher instruction and exploration

• Special science exploration - opportunities outside of the classroom

• Videotapes - related to science units – usually free for deaf students

Specific examples explored in the Rochester, NY area

Note: The following are only samples of the many programs and services available through each agency

Rochester Museum & Science Center (RMSC) & Strasenburgh Planetarium

Source: RMSC Head of Programs, Ramona Englebrecht, the RMSC “School Programs 2003-2004,” and Lyn Nadeau, Head of School and Teacher Programs - 271-4552 x. 521

In-service teacher training programs

• Two-hour Teacher Workshops
Some **features**: information sharing, demonstrations of hands-on science activities & take-home materials

Some **topics**: inquiry-based learning, hands-on science exploration, and astronomy activities

- Teacher training workshops – available evenings, weekend, summer, and superintendents’ days

**In-school programs** - Model lessons - “hands-on, minds-on”- NYS Science Standards

**On-site Programs**

- Hands-on Exhibits, Programs, and Tours – includes NY State Science Standards

- Inquiry Room – K-2 and Special Education to grade 4 – hands-on activities and model lessons

- Student Workshops – RMSC-Exploratorium Partnership (Exploratorium: www.exploratorium.edu)

- Proliferation of programs, exhibits, and material - partnership with Exploratorium

**Community service, authentic, volunteer science projects programs**
• Cooperates with the Science Linkages in the Community (SliC) – see below

• Yearly volunteer “International Coastal Cleanup” Day – community collaboration

• Cooperates with a Water Education Collaborative – see description below

Science Linkages in the Community (SLiC)

Sources: RMSC Head of Programs, Ramona Englebrecht; SLiC flyer (2003); and SLiC website: info@sciencebindings.org.

SLiC is a community-based initiative promoting science, mathematics, and technology education.

Community service and in-service teacher training programs

• **Year-long training program** - for daycare and pre-K school teachers - “Science Co-Explorers”

• **Computer recycling for education program** – providing and refurbishing computers

• **Science exploration projects** - “60 Second Science” public TV show – www.60secondscience.org
**Water Education Collaborative**


The Water Education Collaborative, (WEC) is a coalition of organizations to educate and work collaboratively with the community to protect Rochester water quality. WEC is housed at the RMSC.

**Community service, authentic, volunteer science projects programs**

- Community Water Watch – a volunteer stream monitoring program – K - adult
  
- Annual “International Coastal Cleanup” Day - community collaborative
  
In-service teacher and community education programs

- Teacher Training – through University of Rochester’s water related workshops

- Great Lawns/Great Lakes – helping residents protect water quality

New York State

Board of Cooperative Educational Services

(Source: BOCES website: http://www.emsc.nysed.gov/mgtserv/BOCES)

The Board of Cooperative Educational Services, (BOCES), is an organization that was created in 1948 by an act of the New York State Legislature. The purpose was to provide services that might not normally be economical or even available to smaller, less affluent school districts, by allowing more than one school to share educational programs and services. The regional educational concept of BOCES has so successfully filled its purpose that some 30 other state legislatures are studying the program.

Most programs are instructional in nature, serving students within special education school settings and expanding to provide such programs and services as secondary education in vocational-technical fields; physical and occupational therapy for students with disabilities, and literacy programs for adults. Some BOCES agencies provide support services for mainstreamed deaf and hard-of-hearing students such as interpreters, notetakers, and teachers of deaf students.

What additional programs, materials, or services does BOCES provide for K-12 schools and teachers supporting science instruction?
In-service teacher training programs and classroom resources

- Interdisciplinary science curriculum - emphasizing the national and state science standards
- Teacher in-service program - staff development and classroom support
- Science kits - rented with state aid assistance – stored and refurbished outside the school by BOCES
- Interdisciplinary – K-6 student centered science units - life, earth and physical science
- Video Streaming - teachers or students can dial into a server at Monroe #1 BOCES and watch a lesson being taught - for differentiated science lessons in the classroom.
- Kits examples: Source: http://www.monroe.edu/technologyservices/bosat/sciencekits.html
  - **Balancing and Weighing** - students manipulate objects as they investigate the relationship between balance, weight and volume – grades 2-3
  - **Batteries and Bulbs II** - students investigate electromagnetism and design experiments – grades 5-6

Special science exploration opportunities outside of the classroom

- Challenger Learning Center – a simulated space mission - available from BOCES #1
  - Students use authentic NASA footage of Spirit in 2004 for simulating a Mars launch
  - Provides preparation for the NYS grade 4-8 Science Performance Exam.
In-school, in-service, and on-site programs

- **Educational outreach programs** - K-12 teachers & students – free to participants

- **Cornell Center for Materials Research, (CCMR)** – one of several departments offering services – supported by NSF grants DMR-0079992 and DMR-0317597
  - **Hands-on Science Programs** – K-12 students through adults – free to participants
  - **Summer of 2003** – weekly lessons for deaf students in summer program - microscopes
  - **“Ask a Scientist!”** – in newspaper – students ask Cornell scientists & engineers questions
• Workshops, professional development, and materials for local K-12 teachers

Ithaca, NY

Sciencenter

Source: Sciencenter Educational Program Manager, Mary Lou McGiff and website: www.sciencenter.org

On-site Programs

• K-6 Hands-on programs – exploring various scientific principles such as aerodynamics

• Discovery Space room – self-directed - investigative science - self-created experiments

• Portable Starlab Planetarium – can be taken to schools and classrooms

• Sagan Planet Walk – 1.2 km scale model of solar system – classroom materials available

• Technology Workshops – students develop Macromedia action-script programming

In-service teacher training and in-school programs

• Chemistry Program – activities and kits for classroom instruction – grades K-11
- Portable Starlab Planetarium – teacher training in use of the Starlab

- Hands on programs – K-6 - will come to school classroom.

Ithaca, NY

Ithaca College

Source: Ithaca College Center for Teacher Education Partnership in Teaching Program guide booklet, Alice Rocky, and website: www.ithaca.edu/partnership

In-school, in-service, and on-site programs – Partnership in Teaching program through Ithaca College’s Center for Teacher Education staff – volunteer sharing of expertise

- Lessons in local K-12 classrooms - college professors, staff and student presentations

  - **Environmental topics** – ecosystems – how threatened by human activities

  - **Planetary astronomy** – former NASA employee - students design spacecraft mission

  - **Hearing loss support** – enhancing academic and social opportunities for deaf students

  - Professional development – for school staff development seminars and teacher mentoring
• Modest grants – made available to public schools for science materials

Seeking ideas from fellow teachers, professionals, and students
Examples of ideas learned by one student teacher engaged in action research

• Science labs outside the K-5 classrooms

Some elementary schools have a specially trained science teacher who provides hands-on science projects and experiments in a science laboratory room once or twice a week as a supplement to the classroom teachers' science curriculum. Such a science “specialist” is a good resource person for classroom teachers. Below are ideas gained from a K-5 Science teacher in Columbia, South Carolina.

• Science Classroom Environment: walls of science lab:
  - “The Science Lab Rules” – class management idea -laminated 81/2 X 11 on construction paper, as a border
  - “The Scientific Method” –laminated strips - from an educational store

  Purpose: What do you want to learn?
  Research: Find out as much about your topic as you can
  Hypothesis: Predict the answer to the problem
  Experiment: Design a test to confirm or disprove your hypothesis.
  Analysis: Record what happened during the experiment
  Conclusion: Was your hypothesis correct?
• **Shared resources:** science in general and for a grades 2/3 "Science About Me" unit


• *National Geographic Reading Expeditions, The Human Body* by Catherine Stephens. Excellent pictures and descriptions of what happens with food, air, and blood, in the body.

• Website: science games and movies - “Brain Pop” - http://www.brainpop.com/

• **Resources – teachers and professionals**

• **Deaf Education**

• *Odyssey journal* - practical assistance, advice, and support to parents and professionals in education of deaf students - published by the Laurent Clerc National Deaf Education Center of Gallaudet University - free of charge once sign up on mailing list – http://clerccenter.gallaudet.edu/Odyssey/
• **Captioned Media Program (CMP)** – [www.cfv.org](http://www.cfv.org) - administered by The National Association of the Deaf (NAD). NAD website at [http://www.nad.org](http://www.nad.org) - by the U.S. Department of Education (ED)

• **Captioned videos** - free to public and for Deaf Ed.- many topics related to science - can order online through U.S. Dept. of Education Website: [http://www.ed.gov/index.jhtml](http://www.ed.gov/index.jhtml)

• **National Communication Network** – for parents and professionals of deaf -
  [http://www.deaf.net/](http://www.deaf.net/)

• **General and science education:**

  • **US Department of Education resources for teachers** – many free of charge – examples:

    • Clarification benefits of “No Child Left Behind” law
    • Lesson ideas and materials – over 30,000 lessons – from state, university, and other websites
    • Primary documents, science tools, and teaching resources - from 35 federal agencies
    • Research-based teaching practice information

  • **Teachers of the Deaf (TOD) and elementary classroom teachers’ ideas:**
• **Website resource**: - [www.safesurfin.com](http://www.safesurfin.com) - described as one of the safest websites for children – without inappropriate links

• **Learn from students**: pool student ideas and creativity to help the teacher design lessons and review games for science concepts. E.g. students’ idea: Team Tic Tac Toe with teams names as scientific terms - must answer science question to insert X or O

• **Independent Science Project Idea**: Grade 1
  • Once or twice a month a student does an experiment at home – has kit with purpose directions, materials, report forms, and parental signature line.
  • Conducts, records and presents to class
  • Example: a static electricity experiment uses a balloon and rice
  • Student “scientists” get a Special Discovery Award

• **Educational Resources Information Center, ERIC**, a national information system funded by the US Department of Education, transitional stage as of 2003.
  [http://www.eric.ed.gov/](http://www.eric.ed.gov/) - “Science Education Resources” including digests, bulletins, journals, bookstore, lessons, web links, organizations, announcements, and conferences. Examples:

  • Article: the “National Standards and Benchmarks in Science Education: A Primer” by: Denise Close, Joyce Miller, Lynda Titterington, & David Westwood, September 1996 (Updated June 2003,) from the above source:
• Article: "Norwegian Deaf Teachers' Reflections on Their Science Education: Implications for Instruction," Journal of Deaf Studies and Deaf Education by Roald, Ingvild, 2002

• Elementary, Middle, Secondary, and Continuing Education – Core

• Science for the Elementary Grades - resources for teachers organized by grade.
  Also sample letters to communicate with parents. [http://www.coe.unt.edu/luttrell/]

• Textbooks and websites framed on National Standards:
    units & lessons
    videotapes

  Seeking funds, programs, and materials from science organizations

  The personnel of many of the local museums, science centers, colleges, and organizations
  you explore will have grants or other funds for promoting science education and will be able to
  point to local science organizations that may offer grants, funds, and materials for science
education in public schools. In general, members of the scientific community are happy to assist and direct teachers in creating a successful, authentic, and meaningful science curriculum.

Online searches, phone books, and personal contacts are good places to start to find local, state, and national science organizations that may provide grants or other forms of instructional support. Several of the organizations mentioned here such as the National Science Foundation, the Association of Science-Technology Centers Incorporated, the NEC Foundation of America, and the Noyce Foundation, provide grants and services to many of the museums, science centers, colleges, and organizations mentioned above and may do so for public schools.

**Learn what research says about teaching science**

Probably the best starting place in exploring the most up-to-date research on science pedagogy, deaf education, and self-guided action research would be the libraries and databases of your local colleges and universities. Library personnel are generally among the most service-oriented individuals around and therefore likely to be happy to help you find such educational research in a timely manner.

The personnel and web sites of the various science centers, museums, organizations, and colleges in your area and on this COMETS web site will also be great sources. Each journal, book, and web site will likely lead to relevant research findings that will help you with your teaching. Because of the time constraints upon teachers, particularly first year teachers who are constructing science curriculums from scratch, you may have to begin by just sampling some of the research. Get a general idea of the strategies, themes, and methodologies that are being studied and recommended. Then choose only one or two research study reviews under each topic to examine more carefully.
Your research will likely lead to you to journals, articles, and books which will provide practical tips for implementing the best research-based practices in science and deaf education.

Below are examples of themes you may find, along with a research article as a starting point.

- **Action research** - as a teaching proficiency tool - “Revisiting History: On Bridging Research and Teaching,” Lang, H.G., the *Journal of Deaf Studies and Deaf Education*, (fall of 1996.)


• **Writing-to-learn strategies** – Lang, H.G. & Albertini, J. (2001). Construction of Meaning in the Authentic Science Writing of Deaf Students,
References:


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Kane, Ruth, (1994). Beginning teachers: Survival at the expense of intelligent action, Annual Conference, Faculty of Education, Newcastle, Australia


Quinsland, L.K. (1986). Experiential learning vs. lecture learning with postsecondary hearing-
impaired learners: a study of the potential need for change to occur in instructional methodology. Ph.D. Dissertation, Walden University


Websites:

http://www.deaf.net/


http://www.nas.edu/ National Council on Education

http://www.csus.edu/indiv/b/barricks/Ed%20Research/Action%20research/tsld002.htm

http://usny.nysed.gov/licensing/teachercertlic.html