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ABSTRACT

This paper discusses the Science and Curriculum Reform Project, a model fostering science learning through a systematic approach to language development in young children; the paper focuses on the process and outcome of Component 1 and discusses the development phase of Component 2 of the project. The science curriculum promotes the content and process for learning about life, earth, physical, and technological sciences. Component 1, The Head Start on Science and Communication Program, focuses on grades kindergarten through second and evolved over 5 years of research and implementation at schools in Pennsylvania, New Jersey, and Washington, DC. The initial phase included input from parents and teachers to help shape the inquiry-based strategies for young children learning about the content and process of science. The second phase incorporated curriculum materials and investigative experiments to promote inquiry-based hands-on science as a vehicle for language development with young children. Component 2, the Science and Communication program, targets students in Grades 3 through 5 and follows the inquiry focus by having students discover real life science through research questions that encourage student-facilitated exploration of the science topic. Component 2 is in its first year of development and is being implemented in 4 schools with 16 teachers in Pennsylvania, New Jersey, Michigan, and Washington, DC. The initial phase of Component 2 is establishing a knowledge base on current practices in science education. (Contains 25 references.) (Author/KB)

Science and Communication Curriculum Reform Project: A Content Based Literacy Program

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Abstract

The purpose of this paper is to discuss the Science and Curriculum Reform Project. This project is a model that fosters science learning through a systematic approach to language development. At the Mid-Atlantic Laboratory for Student Success headquartered at Temple University Center for Research in Human and Development and Education, scientists and language specialists have developed a science curriculum that promotes the content and process for learning about life, earth, physical, and technological sciences. The first component is called The Head Start on Science and Communication Program (HSSC). This early childhood science curriculum focuses on grades kindergarten to second. HSSC evolved over five years of research and implementation at schools in Philadelphia, PA, Trenton, NJ, and Washington, DC. The initial phase of the program included input from parents and teachers to help shape the inquiry-based strategies for young children learning about the content and process of science. The second phase of the program incorporated curriculum materials and investigative experiments to promote inquiry-based hands-on science as a vehicle for language development with young children. The second component of the Science and Curriculum Reform Project is called the Science and Communication program. This program targets students in grades 3-5 and follows the first programs inquiry focus by having students discover real life science through research questions that encourage student-facilitated exploration of the science topic. The second component of the project is in its first year of development. There are four participating schools with sixteen teachers grades 3-5 located in Philadelphia, PA, Washington, DC, Trenton, NJ, and Detroit, MI. The initial phase of the second component is establishing a knowledge base on current practices in science education. During this initial phase teachers are currently implementing the first science module 'Gidget's Journey: An Exploration of the Human Body'. The paper will address the process and outcome of component one of the project and discuss the development phase of component two of the project.

Science and Communication Curriculum Reform Project: A Content Based Literacy Program

There is an increasing call among science educators for fundamental changes in course content and modes of instruction to increase students' preparedness in science. Ongoing discussions continue about the best way to teach science to young children during the elementary school years. What best practice is most likely to contribute to children's development and learning is the question that parents, teachers, and the research communities want answered. We know that young children's thinking is expanded through their development as well as through their personal experiences. Children must explore, ask questions, and revise their thinking to accommodate new ideas.

Notable among the science curriculum reform proposals is the American Association for the Advancement of Science's *Project 2061 Benchmarks,* a comprehensive restructuring effort to improve the science literacy of this nation's students. *Project 2061 Benchmarks* provides a framework consisting of standards for science literacy for grades K-12. These standards serve as the basis of the Science and Communication Curriculum Reform Project. The project is a model that fosters science learning through a systematic approach to language development. At the Mid-Atlantic Laboratory for Student Success headquartered at Temple University Center for Research in Human and Development and Education, scientists and language specialists have developed a science curriculum that promotes the content and process for learning about life, earth, physical, and technological sciences.

In deciding how to encourage students to explore the nature and meaning of science while developing their comprehension and expression, teachers are guided in the development that is both explicit and exploratory in nature, taking the best qualities of each, and based on (1) American Association for the Advancement of Science Project 2061 Science Benchmarks, (2) Developmentally Appropriate Practices, and (3) cognitive-linguistic concepts for classroom communication (Hammrich & Klein, 1999). The focus is for teachers to use our learner-centered and teacher-facilitated approach to provide integrated interdisciplinary links to science knowledge development in elementary grade levels.

The science curriculum is conceived within the context of rising public concern over the lack of scientifically literate citizenry; recognition of the significant impact intervention programs in science education have on achieving scientific literacy; and the call for systemic educational reforms in science education in both K-12 and post secondary institutions. Lack of quality K-12 science education is a barrier that limits many school children in post secondary science. Reflecting current national and state reform efforts in science education to provide all students with the opportunity to achieve scientific literacy, the following is advocated:

- Providing active "hands/on-minds/on" instruction;
- Focusing on the big ideas of science instead of isolated facts;
- Integrating science content and process;
- Patterning assessments after exemplary instructional practices;
- Providing a balanced curriculum in the physical, earth, and life sciences; and
- Presenting science concepts thematically to focus on the connections between the science and among other subject areas.

Science content and exploration provide an exciting and natural springboard for skill development throughout the curriculum. The systemic science curriculum reform project focuses on science content: physical, earth, life, and technological sciences and pedagogical processes such as teaching science constructively. Four central themes are targeted: systems, constancy and change, models, and scale. The themes are integrated across the four science content areas. The systemic reform focuses on spiraling the science content across the curriculum to provide a natural progression of science content and pedagogy through the elementary school years.

Synthesis of the Research Base

The current decade has witnessed many voices calling for reform in the teaching and learning of science. The federal government identified six National Education Goals that boasted the United States would be first in the world in science and mathematics by the year 2000 (Culotta, 1990; Vinovski, 1996); and it is presently launching a series of exams in reading and mathematics to improve student achievement and increase the status of American students in an ever-increasing global marketplace (Baker, 1997). Furthermore, policy makers, scientists, and mathematicians have focused on change to develop scientific and mathematical knowledge that will produce a healthy economy and maintain a meaningful democracy.

Current Curriculum Models

Current trends in elementary classrooms tend to incorporate explicit teacher-led activities or exploratory, teacher-facilitated activities (Fradd & Lee, 1999). These two different practices stem from different theories of how children learn and the role the adults play in the learning process.

Explicit curriculum models for elementary school are based upon behavioral learning principles. This theory is linked to learning theories in which cognitive competence is assumed to be transmitted through the process of repetition and reinforcement (Stipek & Byler, 1997). Explicit models use a highly structured teaching approach for acquiring academic skills. The skills emphasized tend to be those assessed by intelligence and achievement tests. Teachers lead small groups of children in structured question and answer lessons. Teachers also spend much time correcting errors to keep children from learning incorrect answers. Workbooks and paper/pencil-oriented activities are generally included in the learning process (Schweinhart & Weikert, 1997).

Exploratory curriculum models suggest that children construct their knowledge by confronting and solving problems through direct experience and use of manipulative objects (Stipek & Byler, 1997). The goal is to create an environment in which children may explore and develop naturally. In such a setting, there are no structured responses. Rather, activities lend themselves to creativity and exploration (Stipek & Byler, 1997). In addition, classroom activities enhance the teacher's role as a facilitator by providing students with the opportunities to engage in activities and interact with their peers.

There have been long-term and short-term studies looking at the different outcomes of these two different approaches toward science education with their impact on cognitive development (Becker & Gersten, 1982, DeVries, 1991; Gersten, 1986; Schweinhart & Weikart, 1997).

Some researchers believe the explicit-directed type of teaching is management driven. Cuban (1993) says, "The basic imperative of elementary schooling is to manage large numbers of students who are forced to attend school and absorb certain knowledge in an orderly fashion." Cuban explains that this demand has led to the development of a curriculum approach that is linked directly to the challenge of managing children. Other researchers believe this type of curriculum is superior to exploratory, child-centered models, especially for children of low-income families.

Delpit (1995) maintains this type of curriculum values basic skills over creative thinking and is necessary for this population because of the value society places on highly structured skills-oriented programs. Schweinhart and Weikart (1998) state that explicit, teacher-directed instruction may lead to a temporary improvement in academic performance at the cost of missed opportunities for long-term growth in personal social behavior. They further support the use of an exploratory, child-centered curriculum to further develop social responsibility and interpersonal skills. Additional research reports that children in child-centered programs display better language development and verbal skills (Dunn & Kontos, 1997).

Both approaches have value in the science education of elementary school children. Some of the issues that have been raised include: which is better for the teacher, which is better for children in developing cognitive competence, and which curriculum model is best for developing the social-emotional development of children. We know that students can benefit from both the explicit and exploratory. "Instead of viewing these approaches as opposing camps, they could be conceptualized as complimentary opportunities for teachers to move between perspectives" (Fradd & Lee, 1999, p. 16).

The major thrust behind scientific thinking in children is a natural tendency to explore and discover one's surroundings. Children's daily playtime activities engage them in "science." Science education in the elementary school classroom unites cognitive development and children's prior knowledge with intuitive scientific theories to formulate new ideas. As they develop explanations about the world around them, children are learning broad scientific concepts. While they are discovering their world, students are questioning and investigating. Rather than looking at the isolated science concepts, science for the elementary student is an introduction to the "big picture."

Learning Environments

New approaches to science education reform emphasize adaptive learning that maximize students' individual competencies. Using an interactive process to enhance students' questioning abilities has been explored by Stone (1994), who emphasizes social interaction discourse and questioning during science lessons. This interactive, analytic approach has led to increased planning and problem-solving skills for young children. Students are taught to view the world in a continuous process of changing ideas. They are asked to describe and communicate those ideas as they make sense of their own leaning, drawing from prior knowledge and asking questions to acquire information. Science distinguishes itself from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations. This interactive inquiry-based perspective is supported by the National Science Education Standards (NRC, 1996).

A cornerstone of the Community for Learning (CFL) comprehensive school reform demonstration program is the Adaptive learning Environment Model (ALEM) (Wang, 1992). This instructional approach provides the infrastructure for blending exploratory and explicit instruction as it supports individual differences in learning and provides effective education to improve schooling outcomes. The program was highly influenced by over two decades of research and broad, field-based implementation of innovative school programs (Wang, Haertel, & Walberg, 1995). CFL "draws itself from the field-based implementation of an innovative instructional program that focuses on school organization and instructional delivery in ways that are responsive to the development and learning needs of the individual child, the research base on fostering educational resilience of children and the youth beset by multiple co-occurring risks, and the forging of functional connections among school, family, and community resources in coordinated ways to significantly improve the capacity for the development and education of children and youth" (Wang, 1998).

Theories of Learning

As our understanding of the process of learning changes from a behaviorist to a cognitive learning framework, so do our conceptions of how the learner is viewed, how learning takes place, and what subject matter should be included in the curriculum. Increasingly, educators have come to view children as active constructors of their own learning rather than as passive recipients of knowledge. According to this view, a major task of the teacher is to create learning environments that are child centered and oriented for active engagement of students in constructing their own understanding, building on their previous experience and knowledge, and communicating their understandings and ideas.

The research base clearly points to language as the medium through which thought and learning about all content areas, including science, occurs. Language is used by humans to construct an inner representation of the world. When this inner representation changes as a function of experiences, so does the language used to map these new relationships. This process does not occur in isolation, but rather is acquired through reciprocal interactions with others, through which children not only learn new worlds but also how and when to use them to reflect what they are observing and to seek clarification for events.

The research base and the resulting conceptual changes have led to the development of new curriculum frameworks and classroom practices that emphasizes the "at promise" potential of the individual student for taking a mentally active creative process in constructing his/her own understanding. Learning is viewed as an interpretive process in which learners actively construct their reality of the world in a continuous social and cognitive process of changing ideas, describing and communicating them as they make sense of their own learning, drawing from prior knowledge and past experience.

Thus, achieving a world-class standard of science literacy among America's next generation of children and youth requires major rethinking in curriculum reform. For too long, our educational system has viewed the technique of learning science as a process of information absorption in which teachers present scientific concepts and information and students memorize the material. Not surprisingly, this type of rote learning antagonizes children and diminishes their natural curiosity, insight, and ability to learn through exploration. As a result, they do not enroll in a sufficient number of science courses, leading to a trend of decline in science literacy. Science learning need not be a series or rote and textbook-dependent activities unrelated to the experiential world; it can and should focus on stimulating, real-world problems that provoke and nurture children's natural curiosity. As the National council for Teachers of Mathematics (NCTM, 1989) notes, "What a student learns depends to a great degree on how he or she has learned it."

Rationale and Design of the Program

The Science and Communication Curriculum Reform Project is designed as a three-year intervention targeting science curriculum at the K-2 and 3-5 grade levels. The systemic science curriculum reform is achieved by designing, implementing, and evaluating a science curriculum that is aligned with Project 2061 Benchmarks and is centered around the programs' learner-centered and teacher-facilitated approach to provide integrated interdisciplinary links to science knowledge development in the elementary grade levels (Hammrich & Klein, 1999; Klein, et.al. 2000).

Through the professional development of teachers, creating of a science curriculum that reflects the intent of the national reform initiatives in the content and pedagogy of science education; and the identification of resources, including online resources the Science and Communication Curriculum Reform Project has a direct impact on students achievement, teachers procedural knowledge of current practices in science instruction, and the overall science curriculum.

The overall goal is to develop a mode for the professional development of teachers to use our learner-centered and teacher-facilitated approach to provide integrated interdisciplinary links to science knowledge and communication skills development.
The proposed systemic reform of the science curriculum achieves the goals and objectives through three components: (a) identifying a curriculum scope based on the National Science Standards; (b) identifying the best from the current resources including online resources; and (c) developing ways to enable teachers to use existing curriculum.

Component One

The K-2 Head Start on Science and Communication curriculum program is based on collaborative research from the fields of science education and cognitive-linguistic development. All program objectives have been aligned with the existing curriculum and are based on the Project 2061 Benchmarks. The program evolved over five years of research and implementation at schools in Philadelphia, PA, Trenton, NJ, and Washington, DC. It is built on 'best practice' where children's development and learning are cultivated through exploration, questioning, and revisions of thinking to accommodate new ideas in science. Specifically, the Head Start on Science and Communication program includes three major objectives: (a) broadening participants' procedural knowledge around three science domains – life, physical, and earth sciences; (b) enhancing participants' ability to use an inquiry approach to learning; and (c) integrating the program with the core curriculum of learning.

The initial phase of the program included input from parents, teachers, and teaching assistants to help shape the inquiry-based strategies for young children learning about life, earth, and physical science. The second phase of the program incorporated curriculum materials and investigative experiments to promote inquiry-based hands-on science as a vehicle for language development with young children. Children gained receptive and expressive language skills as they learned to match, discriminate, categorize, sequence, and associate information while working with peers to understand science concepts, related facts, and solve scientific problems.

Results from 86 first grade students, who engaged in a series of twelve science experiments, indicated that prior to the program they answered an average of 58% of the factual-type questions correctly and 15% of the application-type questions correctly. After learning about topics such as earth surfaces, minerals, changing colors, seeds, and plants, these children answered the factual-type questions with 96% accuracy and the application-type questions with 92% accuracy, indicating a significant gain in knowledge beyond the ;<.05 level for both types of questions. Students improved their knowledge of science concepts along with their ability to answer questions requiring higher cognitive level.

Component Two

The 3-5 Science and Communication Program is the second component in the Science and Communication curriculum Reform Project. Still in the development phase, the program provides integrated interdisciplinary links to science knowledge development in grades 3-5. Two achieve reform in science curriculum, the programs aims to improve three vital areas of science education: curriculum enhancement, resource development, and professional development of teachers.

The framework of the program is closely aligned with the K-2 Head Start on Science and Communication program. As a means of enhancing current science curriculum, the content of the 3-5 program is founded on national science standards and supported by the standards of four major urban cities. In addition to curriculum enhancement, the program identifies the best resources needed for teachers to provide a science rich learning environment in their classrooms. At the crux of the 3-5 grade curriculum is the professional development of elementary school teachers. The overall goal of the program is to design a mode of training for the teachers. The development of this program relies heavily on the input from teachers.

The program is an inquiry based interdisciplinary approach to elementary science education. The program is designed in such a way that it integrates other subject areas into the science curriculum. The curriculum is built on research questions that encourage student-facilitated exploration of the science topic. The program is divided into four modules covering life, earth, physical and technological sciences. The students are introduced to each science concept through the use of a fictional story the story imparts students with background information needed to solve the research questions posed in each of the four science areas.

Phase One

During the first year of program development, the primary objective of the program developers was to establish a knowledge base on current practices in science education. First curriculum development needs were assessed and program participants were identified. Next, the curriculum scope and content was refined and further developed. The culmination of the first year was a three-day professional development with 16 teachers from four major cities: Philadelphia, PA; Washington, DC; Trenton, NJ; and Detroit, MI.

In order to participate in the program, grade 3-5 teachers implementing the Adaptive Learning Environments Model were nominated by school administrators. The teachers were surveyed to determine their commitment to science education, scientific knowledge base and skills in implementing a science rich environment in their respective settings. Teachers were also questioned on their current knowledge of national science standards as well as standards outlined by the state and school district.

Through the professional development of teachers, the program aims to improve the quality of elementary science education. A major concerning of science educators is the lack of science learning introduced at the elementary school level. The main purpose of the three day professional development as to present teachers with procedural knowledge in science; thereby, attaining higher academic accomplishments for elementary students through standards based science-rich learning environment.

During the three-day workshop, teachers were instructed on the development of the science rich learning environment including classroom resources and lesson plans. The professional development included sessions on science curriculum alignment with school with standards, as well as promoting a constructivist approach to science learning in the elementary classroom. Participants also took part inn an all day seminar at the "Franklin Institute Science Museum where they were introduced to the museum as a classroom resources. Also at the professional development workshop, teachers were asked for input on the first science unit. As a group, all aspects of the pilot curriculum were discussed. Participants read and leveled the first modules story. The group modeled science activities pertaining to the story. Participants left the workshop ready to pilot the first module: 'Gidget's Journey: An Exploration of the Human Body'.

Phase Two

Teachers are in the process of piloting the first module. Results will be forthcoming by the end of the summer 2002. The first module is entitled: 'Gidget's Journey: An Exploration of the Human Body'. To begin the first module teachers have students' answer the pre assessment questions which center on the content of the story they will read. The fictional story centers around the organs and systems of the body.

Students are introduced to the various organs and systems by reading about how Gidget and her dog, Madame Curie, travel through the body in a bubble jet. After students read the story they then begin their explorations by investigating various science questions related to the story (i.e. Do your lungs lose capacity when you're winded?). After the students have completed all their investigations they reflect in their science journals with the various questions provided. At the conclusion of the module the students take the post assessment. The module also includes all the background content information for the students and teachers along with the vocabulary associated with the story and all the standards the module addresses.

There will be four modules per grade level for a total of 12 modules in our science areas: life, earth, physical, and technology. Two other modules in the process of development include: 'Wrigley's Voyage: An Exploration of the Inside of the Earth' and 'The Universal Hunt: An Exploration of the Solar System'. In 'Wrigley's Voyage: An Exploration of the Inside of the Earth' we find a boy named Wrigley and his friend Homer, an earthworm, exploring beneath the earth. In 'The Universal Hunt: An Exploration of the Solar System' we find Quasar and Solara Moon traveling through space. Each module is centered around a fictional story that is further investigated by the students through the explorations.

Conclusion

Gaining knowledge about scientific processes and principles while increasing cognitive, linguistic, and literacy skills is a challenging and important task. Whether information is acquired though explicit, teacher-directed methods or through exploratory, childe-centered methods, it cannot be assumed that one method of learning is better then the other, or that one should replace the other. Not all children learn in the same way and they may not learn equally well using only one method. Often, we find that it is best to combine more than one method to help children learn to their maximum potential. In an effort to motive children to explore, understand, analyze, and create, teachers are encouraged to combine both explicit and exploratory teaching methods. This way students are given basic information fro m which to begin and to peak their curiosity for continued exploration. The Science and communication curriculum Reform Project unites language development and science inquiry with a multifaceted Communication

Program unites language development and science inquiry with a multifaceted curriculum to meet the needs of teachers and students within our diverse educational arena of the 21st century.

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