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ABSTRACT

Mathematics education is experiencing a tremendous change. Integrating literature into mathematics instruction is one of the methods used to make this new vision a reality. Children's books that explore the mathematical world often present metaphorical mathematical ideas. This paper presents a review of integration literature on mathematics instruction. The history of this issue, other major issues, controversies, programs, and contributors are discussed. Information on synthesis and analysis of research and literature is also presented. It is concluded that the integration of literature and mathematics will enable students to see the relevancy of mathematics in their daily lives and force teachers to examine their teaching styles and create lessons that are exciting, motivating, interesting, and promote higher-order thinking skills. Contains 28 references. (ASK)

Integrating Literature Into Mathematics Instruction

Literature Review

Michelle F. Ezell

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Introduction

Mathematics education is experiencing a tremendous change. According to the Mathematics Framework, "the United States must restructure the mathematics curriculum-both what is taught and the way it is taught - if our children are to develop the mathematical knowledge (and the confidence to use that knowledge) that they will need to be personally and professionally competent in the twenty-first century...What is required is a complete redesign of the content of school mathematics and the way it is taught (1992). Times are challenging, however, there must be an understanding that reform is necessary. As educators we must promote mathematics instruction that will enable all students to function as informed citizens in a rapidly changing and technologically complex society. "These reforms are promoted by the changing needs of our society, which demand that all students become mathematically literate to function effectively in a technological world" (Curriculum and Evaluation Standards for School Mathematics, 1992).

Integrating Literature into mathematics instruction is one of the methods to make this vision a reality. Since mathematics is everywhere in the world around us, children's books that explore the mathematical world often present metaphorical mathematical ideas (Lewis, Long, and Mackay, 1993).

Mathematics and Literature have strong links and the

benefits of using them together are many. Literature has an aesthetic and universal appeal to both adults and children. The magic of telling and reading stories should be offered to all children. Most children beginning school have already had some experience with books and this has assisted in shaping their perceptions of the world. Books extend and develop children's ideas of the world, but at the same time these ideas are bounded by the constraints of the story. The familiarity of the book or the story gives children a structure within to explore mathematics. Such a structure provides children with a defined context within which they can manipulate and develop mathematical concepts. According to the Mathematical Framework "Students need contexts in which to think and communicate" (1992).

Within various texts and illustrations, there are opportunities to involve children in problem solving, pattern and order activities, and classification, as well as other mathematical skills. Children are also provided with experiences which demonstrate that mathematics and literature are interrelated and not separate entities.

Bringing mathematics and literature together also assists the teacher in integrating the curriculum. This approach includes other curriculum areas such as science, social education, physical education, visual and language arts. "There is no more powerful vehicle for meeting new goals in mathematics that the use of children's literature

in the classroom" (Whitin, 1992).

Statement of the Problem

There is much concern in this country about mathematical competence of our young people. "Although studies show a slight improvement in the mastery of basic facts, there still appears no marked process in the areas of problem solving and critical thinking" (Whitin, 1992). Children may be able to correctly answer a problem such as (7 x 4 =) as an isolated fact on one part of a test, but many cannot solve this same problem when it appears in a story: "If John has four bags of marbles how many marbles does he have?" Students are somewhat competent at symbols, but unsuccessful at solving problems and thinking critically. Hence, students leave school with a bad taste for mathematics.

What vehicles will motivate children to become mathematically competent to become mathematically competent for a rapidly changing and technologically complex society? Several vehicles will be discussed and analyzed.

What is the role of an educator in the implementation of the mathematical standards? Research and theory in this area will be examined.

What means of assessment are needed to evaluate the work of students? Specific strategies and techniques will be discussed.

Definitions

The following terms are important to know in order to fully understand the importance and effect of integrating literature into mathematics.

Assessment

The word assess in its derivation means, "to sit beside," to "assist the judge". It is the process of determining what students know. "An active part of instruction in mathematics is checking what it is that students understand, getting feedback from students, and then using this information to guide the development of subsequent learning experiences" (Webb & Briars in Teaching & Learning Mathematics in the 1990's, 1990).

Cognitive Style

This term is sometimes called 'Learning Style'. It is "the actual way in which an individual accepts and processes information while learning" (American Educators' Encyclopedia, 1991). Prior experiences often help to shape the learning style used by the learner. Therefore, the teacher must establish a learning environment that helps the learner to establish and develop the desired creative learning style.

Critical Thinking

This term is defined as "the ability to judge and evaluate information and/or evidence, drawing conclusions that are objective and logical (American Educators' Encyclopedia, 1991). Critical thinking is developed

within the elementary schools. It is an important part of a school curriculum - language arts, mathematics, social science and science. "During the 1980's, several states have initiated programs of requirements that stress the teaching of thinking" (Encyclopedia of Educational Research, 1992). As educators we must emphasize higher order thinking skills within instruction.

Integration (Subject Matter)

"The combining of subject matter into broad fields of study, into a core curriculum, or into a combined field such that subject matter is highly synthesize" (American Educator's Encyclopedia, 1991). It is worth noting that 'integration' is a loaded term among educators. "Integration carries in educational discourse strong connotations of approval that the phrase 'subject-based' lacks" (A Critical Dictionary of Educational Concepts, 1990). 'Integration' implies unity (which seems generally to be approved), while 'subjects' imply departmentalization, or divisional structure (all of which are widely regretted).

Literature

"Those books, poems, essays, letters, documents, and other printed materials considered to have social, cultural, or intellectual value and interest" (American Educators's Encyclopedia, 1991). Literature has a major role to play in teaching. Literature provides experiences that are not otherwise available to the reader.

"Professionals have adopted children's literature as a medium of instruction because of its natural language and structures, interest to children, and coverage of important themes and topics" (Encyclopedia of Educational Research, 1992).

History

Historically, mathematics has always had a place in the culture and traditions of societies. The Greeks explored mathematical ideas such as infinitesimals through paradoxical stories such as 'Achilles and the Tortoise'. If Achilles travels 10 times as fast as the tortoise, and gives the tortoise a head start, will he over-take the tortoise?' (Griffiths & Clyne, 1988). For the Greeks, geometry described the universe, both physically and metaphysically. The four elements, earth, air, fire, and water, were composed of fundamental particles in the shape of four of the regular polyhedra. Numerology was an important part of many cultures and was used to interpret and create texts. Composers such as J.S. Bach and Bela Bartok incorporated numerology into their musical scores. The classic book of wisdom is based on numbers derived from the throwing of sticks and coins. Certain numbers also seem to have mystical and religious qualities; especially 3, 7 and 12 which appear in the Bible, fairy stories, folk tales and legends (Griffiths & Clyne, 1988).

Historically, children's literature has been variously described and Newberry (1713-1767), the English publisher "who first believed in children as discriminating patrons

of books" (The Encyclopedia of Education, 1971). Since that time there has been a gradual transition from the deliberate use of didactic literature to the provision of literature to entertain and inform. "Perhaps the most dramatic development in children's literature in the twentieth century has been the picture-story book" (The Encyclopedia of Education, 1971). The picture book traces its origin to the nineteenth century. Outstanding artists such as Randolph Caldecott, Kate Greenaway, and Walter Crane were at work. However, because of high cost the picture-book did not come into its own until the 1930's. The great depression of World War II slowed down the picture - story books. However, artists such as Dorothy Lathrop, Ludwig Bemelmans, and many others continued working during the war years. This perseverance brought the picture-story books to their present position. The field of creating a picture-story book has proven to be a success with children between the ages of two and eight, despite their non-existent or limited reading skills (American Educator's Encyclopedia, 1991). After the turn of the century, talented writers turned their attention to the domain of young readers. Children could explore life through literature.

The subjects 'Mathematics' and 'Literature' have been a part of curriculum since the beginning of education. It has been recently, there have been many calls for reform of schooling, and in particular there has been major

rethinking of school mathematics (Linquist, in National Council of Teachers of Mathematics, 1989). The link between bringing Mathematics and literature together is an imperative tool in integrating the curriculum. "The integration of children's literature can be an important vehicle to use when exploring various mathematical concepts" (Whitin and Wilde, 1992 in Whitin and Gary in 1994).

Major Issues, Controversies, Programs and Contributors

The necessity for reform of school mathematics has developed a strong link between mathematics and literature. Reform is here. The Mathematical Framework "provides a road map for change and offers many paths that lead toward the destination" (Framework, 1992). The National Council of Teachers of Mathematics (NCTM) focused on a program known as 'An Agenda for Action', which resulted in recommendations called School Mathematics for the 1980's (Stepelman in Teacher's Resource Handbook, 1993). The purposed curriculum for school mathematics stated that:

1. Problem solving should be the focus of school mathematics.
2. Basic skills should mean more than mere computational facility.
3. Calculators and computers should be incorporated into the curriculum at all levels.
4. Student learning should be evaluated by both traditional and other-than-traditional means.

5. More study of mathematics should be required of all students.

6. A greater range of elective courses should be offered.

(Teacher Resource Handbook, 1993) During the late 1980's, NCTM's commission on Standards for School Mathematics directed four working groups to draft a set of standards for mathematics curricula which would essentially reform every aspect of school mathematics in American schools (K-12). The four working groups (contributors) consisted of classroom teachers, supervisors, educational researchers, teacher educators, and university mathematicians. The two documents which were issued as a result of this collaboration were: Curriculum and Evaluation Standards for School Mathematics (1989) and Professional Standards for Teaching Mathematics (1991). These two documents now form the cornerstone of **reform** in school mathematics for the 1990's. These reforms were prompted by the changing needs of our society, which demand that all students become mathematically literate to function effectively in a technological world (Curriculum and Evaluation Standards for School Mathematics, 1992). These documents offer recommendations for all aspects of school mathematics - curriculum, teaching strategies, evaluation techniques, professional development of teachers, and even the public's responsibilities. The proposed curriculum calls for an "integration of several different content areas

such as mathematics, art, history, geography, music, current events, and sports" (Stepelman in Teacher Resource Handbook, 1993). It encourages critical thinking, problem solving, and recommends the use of calculators and computer technology.

An issue to be addressed is that of technology. "Technology has made possible many of the new creations in mathematics, and we must be responsible to technology" (Lindquist, 1989). Students have often been persuaded by the power of a paper-and-pencil algorithm; they know how to do it, but they do not know what it really does or why. "In the past, mathematical classrooms were dominated by instruction and performance of rote procedures "to get the right answer". The curriculum and Evaluation Standards supports the view of school mathematics as a sense-making experience encompassing a wide range of content, instructional approaches, and evaluation techniques" (Curriculum and Evaluation Standards for School Mathematics, 1992).

The role of computation in the mathematics curriculum will be much the same as it has always been and that is to furnish the individual with useful skills and to facilitate further learning in mathematics.

One of the major criticisms of the way computation has been taught is the over-reliance upon drill as the main instructional strategy. Although drill remains an important activity in teaching computation, we must use

more efficient approaches. A new trend toward more frequent, briefer periods of practice seems to offer promise for effective drill. According to Coburn, "drill must follow adequate understanding" (1989).

The relationship between reform, technology, and computation lead into a controversial issue of standardized tests. Current standardized tests focused heavily on written computational skills and symbol manipulation. They pay less attention to problem solving and higher-order thinking skills. Calculator usage on these tests has not yet been established. If there has been major calls for reform in school mathematics, why is it that standardized tests do not test the way educators are teaching? This controversial issue has been brought up several times amongst educators and will continue to be an issue until the tests change.

Another issue to be addressed is that of time. As reform enters our schools, teachers need support to make the new mathematical programs a reality. The Mathematical Framework suggest that teachers need time to collaborate with peers: plan together, visit classrooms, review student work, make judgments about program strengths, weaknesses, and overall effectiveness. Also time is needed - to prepare for class and plan, continuing to learn mathematics, respond to student work (1992). With the demands of any new program, the support of time is a necessity.

Synthesis and Analysis of Research and Literature

Throughout the research an alert sign has continued to flash. There is much concern in this country about the mathematical competence of children. Reform is taking place. Significant changes need to occur within mathematics education. In regard to the integration of literature and mathematics, there are three central questions that seem to be of importance:

1. How does the integration of literature into Mathematics instruction enable children to become mathematically literate to function in a technological world?
2. What is the process in which children learn?
3. What means of assessment are needed to evaluate the work of students?

How does the integration of literature into mathematics instruction enable children to become mathematically literate to function in a technological world?

Mathematical ideas and concerns are present in literature of all kinds, and indeed the purposes or functions of mathematics and literature are closer than might at first appear. One function of mathematics is to order the world around us. So does literature. Mathematics is concerned with classification. So is literature. Mathematics is concerned with problem solving. So is literature. Mathematics looks at relationships. So does literature. Mathematics involves patterns. So does literature. The conclusion of this

analogy is the Mathematics and literature have strong links, both in content and in structure.

The (NCTM) calls for significant changes in mathematics education. It advocates new goals for students that include: 1) learning to value mathematics; 2) becoming confident in one's own ability; 3) becoming a mathematical problem solver; 4) learning to communicate mathematically; and 5) learning to reason mathematically. These goals imply that students need to be engaged in experiences that help them "understand and appreciate the role of mathematics in human affairs" (Curriculum and Evaluation Standards for School Mathematics, 1992). NCTM also urges students to no longer crunch numbers together in silent practice, but do more writing, reading, and discussing of mathematical ideas with each other. The link between literature and mathematics become a significant power which will enable students to achieve these important mathematical goals.

The link between literature and mathematics can be analyzed through meaningful context to mathematical learning. Children's literature can help learners value mathematics. "It is through books that children seen people using mathematics for a variety of purposes" (Griffiths & Clyne, 1991). Children's literature helps learners build their confidence in their own mathematical abilities. "Success in mathematics demonstrates competency. Thinking that one is competent enhances

intrinsic motivation" (Holmes in Teaching and Learning Mathematics in the 1990's, 1990). Books provide a non-threatening avenue for the exploration of various mathematical ideas. Children's literature encourages learners to be mathematical problem solvers. "A primary goal for the study of mathematics is to give children experiences that promote the ability to solve problems and that build mathematics from situations generated within the context of everyday experiences" (Curriculum and Evaluation Standards of School Mathematics, 1992). Children's literature provides a meaningful context for children to communicate mathematically. "Children develop mathematical concepts through the use of informal language, and move gradually towards a formal terminology and a symbolic method of recording" (Griffiths & Clyne, 1991). Children's literature supports learners in reasoning mathematically. "In a conducive setting children use what they already know to develop personally meaningful solutions" (Yackel, Cobb, Wood, Wheatly, & Merkel in Teaching & Learning Mathematics in the 1990's, 1990).

What is the process in which children learn? The elementary school years are crucial in a child's cognitive and affective development. Research has explored that "learning is the growing and connecting of structures in the brain" (Smilkstein, 1993). Learning is based on prior knowledge. Students are born with a cognitive system that

is made to, knows how to, and is impelled to learn and think. Research indicates that "learning depends on children's knowledge on that, in many cases, mismatches between what children know and what curricula assume they know are the root cause of underachievement" (Bruer, 1994). "Teachers must understand in a meaningful way the mathematics will be taught, know who to help children construct these meanings, know what problems children will have in constructing these meanings, and have confidence in their own ability to think about mathematical situations (Encyclopedia of Educational Research, 1992).

Learning is physiological. There are brain changes that occur during learning. As children begin to learn, knowledge is expanded. New knowledge begins with the old knowledge. As teachers become familiar with this process they can find familiar concepts that students can relate to and build upon that knowledge. As teachers, our role of implementing the standards is important. We need to build student's self-confidence and nurture their natural curiosity. We need to challenge them with rich problems through which they will learn to value mathematics and appreciate the order and beauty of mathematics; to provide them with strong foundation for further study; and to encourage their mathematical ability and power" (Curriculum and Evaluation Standards for School Mathematics, 1992).

What means of assessment are needed to evaluate the

work of students?

Evaluation must be an integral part of teaching. A primary component is an on-going assessment of what goes on in the classroom. The Curriculum and Evaluation Standards states that we must learn to implement a variety of assessment instruments and not depend solely on pencil-paper tests only. Tools such as observations, interviews, projects, portfolios, diaries, reports, and tests provide a more complete picture of what children understand and are able to use (1992). Assessment should be incorporated into the everyday routines of the classroom (Sgroi, Gropper, Kilker, Rambush, & Semonite, 1995).

The integration of literature into mathematics is a powerful vehicle in which can be a useful approach to empower mathematics. Children need to be able to function properly in a demanding technological society. Mathematics should be a living, exciting activity for children. It can give children a tool for solving real problems and a way of looking at, and communicating about, their world that adds understanding and insight. This can be accomplished through the wonderful world of children's literature.

Conclusions

It can be concluded that from the research there is no doubt that the new framework will be implemented successfully. Not only should the integration of literature be implemented, but of all subject matters as well.

The integration of literature will enable students to see the relevancy in which mathematics plays in their daily lives. This will have a positive effect on the attitude of students concerning mathematics. They will be motivated and their feelings of anxiety or fear concerning word problems will slowly fade. Students will have a confidence of themselves. They will be able to achieve their mathematical potential.

Further, integrating literature into mathematics will force teachers to look at their teaching styles, and create lessons that are exciting, motivating, interesting, and at the same time promote higher-order thinking skills. Hence, our students, the citizens of tomorrow, will expand their knowledge, to interpret information, to make reasonable decisions, and to solve increasingly complex problems using various approaches and tools, including calculators and computers (Curriculum and Evaluation Standards for School Mathematics, 1992).

Recommendations

As a result of this research there is undoubtly a need for staff developments on delevoping methods and techniques for imlementing units that consist of mathematics through literature. During these staff developments, teachers can create exciting, motivating lesson plans that promote higher-order thinking skills and the goals of our students becoming mathematically literate.

Another recommendation is for school districts to carefully examine their existing mathematic programs. Many different agencies are publishing new math curricula in accordance with the Mathematic Framework. However, not all of these publishings meet the total needs of the students. Text books with mere drill and practice is of no value if there is not a background understanding. If a school is considering to adopt a new mathematics program, be aware of the curriculum development within the program.

Another recommendation is to implement assessment in curricular areas. As educators experiment with this new assessment, they can tract students learning and the powerful thinking skills they will demonstrate. Implementing new assessment tools will be challenging to both educators and students, however, experience is the key to developing a successful program.

The final recommendation is to the profession. With a rapid changing society and a call for mathematical reform, it can not be assumed that everyone will understand what is taking place. In order for this prestigious profession to continue, a well rounded knowledge of reform needs to be implemented throughout. Administrators and educators need to take time to collaborate and unite their mathematical empowerment within the development of present-day curriculum.

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