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ABSTRACT

This paper describes a mathematics-centered thematic unit for 5th graders which organizes all the topics in the Houghton Mifflin Mathematics Program by combining critical thinking and whole language frameworks to help students retain, understand, and make active use of knowledge within and across domains. The unit connects inquiry, goals, critical concepts, critical issues, critical strategies, and performance-based outcomes. Critical strategies included in the program are: critical thinking, active approaches to learning, and assessments of understanding. Program materials integrate: (1) David Perkins' knowledge-as-design methods of critical thinking; (2) the National Council for Excellence in Critical Thinking framework for teaching and assessing critical thinking; (3) Lytle and Botel's Pennsylvania Framework for reading, writing, and talking; and (4) Howard Gardner's theory of multiple intelligences to help students read and remake the world. Includes 12 references. (Author/MKR)

Believe those who are seeking the truth.
Doubt those who find it.
Zen proverb

Third Millennium Mathematics

(a thematic unit for helping 5th graders to retain, understand and make active use of mathematical knowledge)

by

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Abstract

A math centered thematic unit for 5th graders, " Third Millennium Mathematics " combines critical thinking and whole language frameworks to help students retain, understand, and make active use of knowledge within and across domains. The unit connects inquiry, goals, critical concepts, critical issues, critical strategies, and performance based outcomes. David Perkins' knowledge as design method of critical thinking, the National Council for Excellence in Critical Thinking framework for teaching and assessing critical thinking, Lytle and Botel's PA Framework for reading, writing, talking, and, finally, Howard Gardner's theory of multiple intelligences are integrated to help students read and remake the world.

Description

As a thematic unit, Third Millennium Mathematics will organize all the topics in the 1994-1995 Houghton Mifflin Mathematics Program for 5th graders at Joseph Pennell Academics Plus public school in Philadelphia, PA. Also, it will connect inquiry, goal, concepts, issues, strategies, outcomes, and the instructional program. Finally, the unit blends systematic instruction in critical thinking, whole language, and alternative assessments of understanding.

Inquiry

Throughout the unit, students will have a lot of chances to find inquiries of their own. For the teacher, however, two related questions will be pursued:

1. How can students be taught to understand mathematical knowledge?
2. What mathematical knowledge is worth understanding?

Goal

David Perkins offers three goals in *Smart Schools: From Training Memories to Educating Minds.* He says schools should help students to retain knowledge, understand knowledge, and use knowledge actively. (Perkins, 1992)

Likewise, in Third Millennium Mathematics, **students will retain, understand, and make active use of knowledge about time and space as embedded in Houghton Mifflin Mathematics, Reading, and Social Studies programs.**

This is a strategic goal aimed at helping them to connect knowledge and two fundamental concepts of life. Or as Paulo Freire says, students learn to read and remake the world. (Freire, 1993)

Critical Concepts

The concepts time and space are embedded in the Literature based, Houghton Mifflin Reading, Mathematics, and Social Studies programs in use at Joseph Pennell Academics Plus elementary school, Philadelphia Pennsylvania. These ideas also appear in life. They make up the critical concepts presented in the thematic a unit.

In addition, the concept **understanding** is essential to the inquiry. David Perkins, Co-Director of Project Zero with Howard Gardner and a Senior Research Associate at Harvard University, says understanding is the ability to **" perform in a variety of thought-demanding ways with the topic, for instance to: explain, muster evidence, find examples, generalize, apply concepts, analogize, represent in a new way..."** (Perkins, 1993)

All year, students and the teacher will struggle to think critically about this set of fundamental concepts: time, space, understanding.

Critical Issues

The most important issues will come from student inquiries, but it is possible to begin with a model case. Take Yves Coppens' " East Side Story: The Origin of Humankind. " His model of human evolution, as presented in the May 1994 edition of *Scientific American,* describes issues of time and space. Coppens had wondered when humans emerged as a species and how they spread from the African savanna east of the Rift Valley to the rest of the world. Long standing scientific issues of time and space are resolved in his model. (Coppens, 1994)

Or take David Bohm's ontological interpretation of quantum mechanics. At the heart of Bohm's cutting edge theory lies the following issue: how are time and space ordered in the physical world.

And of course, Jean Piaget spent five decades exploring issues related to how children construct knowledge, in general, and how they construct knowledge about time and space, in particular.

In Third Millennium Mathematics, students will have chances to explore issues that naturally flow from their experiences of time and space in Mathematics, Science, Social Studies, Literature, and life. These explorations may continue well after the instructional year is over.

Critical Strategies

Just a handful of strategies for learning will help students retain, understand, and make active use of knowledge.

Critical Strategy One: Critical Thinking

Knowledge as design will be the introductory method of critical thinking. David Perkins, author of the knowledge as design method, claims that any human made object or idea is a " structure adapted to a purpose." Thus, a piece of chalk, for example, will have a purpose, structure, model case, and argument: What is it for? What is it made of? What is an example of it? How does it work? Does it work well? What pattern connects it to other writing instruments? (Perkins, 1984)

Likewise, with our " knowledge as design colored glasses " on, an idea, such as time, space, base 10 blocks, number sense, or divisibility can be seen in terms of these questions:

- What is the **purpose**?
- What is the **structure**?
- What is a **model case** of it?
- What are **arguments** about it (explanatory, evaluative, deep explanatory)?

These four design features help students--and teachers--to read the word and write to remake the world. Also, Perkins adds a fifth design feature that increases the utility of his system: Invent your own design. (Perkins, 1984)

When students become fluent in using knowledge as design to reason, read, write, talk, and listen, the **basic elements of thought** from NCECT's framework for teaching and assessing critical thinking will be added to their tools for retaining, understanding, and making active use of knowledge.

The basic elements of thought are these: **purpose, issues, point of view, concepts, assumptions, information, inferences, conclusions, implications, consequences.** (Proceedings of Forums, 1993 and 1994)

Students will learn how to use the basic elements of thought for critical reading, writing, and listening.

" All thought has a universal set of elements, each of which can be monitored for possible problems," says Richard Paul, president of the National Council for Excellence in Critical Thinking Instruction.

" Are we clear about our purpose or goal? about the problem or question at issue? about our point of view or frame of reference? about our assumptions? about the claims we are making? about the reasons or evidence upon which we are basing our claims? about our inferences and line of reasoning? about the implications and consequences that follow from our reasoning? Critical thinkers develop the skills of identifying and assessing these elements in their thinking and the thinking of others."

Paul says making explicit use of the basic elements of thought helps a critical thinker to explore the background logic of both self and other. This dialectical, dialogical process can ferret out strengths and weakness in a given point of view and thus improve the thinking. (Paul, 1992)

Critical Strategy Two: Active Approaches to Learning

Featured throughout the thematic unit are active approaches to learning. Students use KWL, double entry journals, SQP3R, real talk, cooperative learning, story maps (and other graphic organizers), television story boards, critical reading strategies, the doubting and believing game, literature studies, issue papers--all are thoughtful ways of learning. Specifically, the PA framework will be used to organize reading, writing, talking, and listening activities so students will be active learners throughout the year.

Lytle and Botel drew from the experiences of numerous successful teachers and the research base for reading and writing to design the PA framework, a whole language model. Essentially, their framework has three major components: four lenses, five critical experiences, and authentic assessments.

For them, making-sense, language, social, and human lenses provide a way of seeing instruction. Five critical experiences, reading, writing, extension of reading and writing, language, and learning to learn, help to design activities that require active learning. Finally, they see authentic assessments as a vital part of the teaching/learning process. (Lytle and Botel, 1990)

The Perkins, NCECT, Lytle and Botel frameworks overlap because they share a primary emphasis on active learning as a means of developing literacy. Also, each of these frameworks provides a high touch component to any high tech introduced into the classroom. Finally, active approaches such as these aim at helping students to remember knowledge, understand concepts within a domain, and use the concepts gained in one domain to make connections with a different domain. Active approaches help students to see how time and space in Mathematics relates to time and space in Literature, Science, Social Studies, Art, Health, Physical Education, and Music.

Critical Strategy Three: Assessments of Understanding

Howard Gardner's theory of multiple intelligences guides selection or design of assessments of understanding throughout the unit. His theory suggests that linguistic, mathematical, musical, kinesthetic, spatial, interpersonal, and intrapersonal intelligences more accurately describe the range of human abilities to be considered in assessing performances of understanding. In other words people can be smart in more than one way. (Gardner, 1983)

Moreso, he defines intelligence as the ability to " solve complex problems or create intellectual products of value in one or more cultural settings." Performance based assessments can measure the ability to solve complex problems or create intellectual products in two or more intelligences. (Gardner, 1983)

In Third Millennium Mathematics the National Intellectual Standard guides assessment of solutions to complex problems and creations of intellectual products (i.e. performances of understanding). Using the National Intellectual Standard, students and the teacher will assess performances for these qualities: **clarity, precision, accuracy, relevance, consistency, logic, significance, good reasons, evidence, depth, breadth, and fairness.** (Proceedings of forums, 1993 and 1994)

Lastly, the Student Progress Record Book (SPRB) documents authentic assessments of understanding and describes both individual and class progress in retaining, understanding, and making active use of knowledge with the mathematics domain and across the curriculum.

Outcomes

Three related outcomes should result from Third Millennium Mathematics:

1. Students will be better able to retain, understand, and make active use of knowledge in Science, Mathematics, Social Studies and Literature.
(Perkins, 1992)
2. Students will develop " literate voices " (people who can reason, read, write, speak, and listen well for fun and profit).
(Vilaume and Worden, 1993)
3. Students will be better able to " solve complex problems and create intellectual products of value in one or more cultures."
(Gardner, 1983)

Students will demonstrate these outcomes (performances of understanding) in portfolios of written work, publications, and enactments across the seven intelligences. Their solutions to complex problems and creations of intellectual products will be assessed with a holistic scale based on NCECT's National Intellectual Standard.

Instructional Program

The instructional program has the Houghton Mifflin 5th grade mathematics program at its core. That means certain generic features are already in place. For example, each of the 14 chapters offers management objectives, cooperative problem solving activities, two minute math activities for lesson warm ups, suggested manipulatives, cumulative reviews and problem solving reviews for assessments of understanding. What Third Millennium Mathematics adds to these generic features are writing to learn and learning to write. First, students use the KWL learning strategy as a framework for each lesson. That means they connect prior knowledge, inquiry, and summaries of what was learned.

They use knowledge as design as a means of organizing their reasoning about key concepts that are explicitly in the text: number sense, base 10 blocks, divisibility, measurement, geometry, and statistics, for examples. That means they examine any given mathematical object or idea for purpose, structure, model case, and arguments--multiple perspectives of critical thinking or what Richard Paul calls multilogical thinking. They use NCECT's basic elements to explore mathematical ideas, such as time and space, in depth. That means they question purpose, concepts, point of view, issues, information, assumptions, inferences, conclusions, consequences, and implications of big ideas in mathematics within and across domains.

Besides writing to learn, students learn to write. This thematic unit requires one publishable, knowledge as design paper per report card period. The paper must be about a big idea in mathematics. Students might write about number sense, base 10 blocks, time and space or self selected mathematical topics including biographies of mathematicians and scientists. Also, they might write reviews or design television story boards about such classic novels as H. G. Well's *Time Machine*. They might write original science fiction stories about time travel. Finally, they might write research reports about new scientific ideas such as faster than light phenomena. In addition, students might use the NCECT framework to explore ideas about time and space emerging from their work in Literature, Social Studies, Music, Science, Art, Health, and Physical Education.

All informal and formal assessments (graded solutions to complex problems or intellectual products) of both writing to learn and learning to write activities rely on the National Intellectual Standard. That means outcomes are judged for clarity, precision, accuracy, relevance, consistency, logic, significance, good reasons, evidence, depth, breadth, and fairness. (Proceedings of forums, 1993 and 1994)

In summary, Third Millennium Mathematics thematic unit is first of all inquiry based. It organizes reflections on the questions how can students be taught to understand knowledge in Mathematics and what knowledge is worth understanding? Secondly, the unit offers a strategic goal that organizes lessons and activities to help students retain, understand and make active use of mathematical knowledge both within the domain of Mathematics and across other domains. Thirdly, it connects critical thinking methods, whole language, and assessments across seven intelligences. Fourthly, it ends with measurable, performance based outcomes that link standard and alternative assessments. The unit is a holistic approach for developing language and thought.

Finally, as a framework specific enough to explore one domain in depth but broad enough to connect multiple domains, Third Millennium Mathematics echoes the dream Paulo Freire writes about in *Pedagogy of the City*.

" We dream of an effective public-school system that will be constructed step by step within a space of creativity. We dream of a democratic school system where one practices a pedagogy of the question, where one teaches and one learns with seriousness, but where seriousness never becomes dullness. We dream of a school system where, in teaching necessarily the content, one teaches also how to think critically."

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