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Do the Great While it is Still Small: Humanistic Teaching in the Elementary School

John Eichinger
California State University, Los Angeles

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California State University, Los Angeles

"Do nondoing,
strive for nonstriving,
savor the flavorless,
regard the small as important,
make much of little,
repay enmity with virtue;
plan for difficulty when it is still easy,
do the great while it is still small.
The most difficult things in the world
must be done while they are easy;
the greatest things in the world
must be done while they are small."

- from the *Tao Te Ching* by Lao Tzu, translated by Thomas Cleary (1991, p. 48)

These words from the *Tao Te Ching* offer practical guidance regarding the teaching of humanistic mathematics and science. If mathematics and science are indeed critical human endeavors, inextricably tied to culture and social interaction, and therefore integral to a full understanding of the human condition, then as humanistic disciplines they must become integral aspects of school curriculum. "Do the great while it is still small," suggests that educators begin teaching math and science as humanistic disciplines at the earliest possible point, that is, in elementary schools. We cannot afford to wait until students are in college to present math and science in a humanistic context. Research has shown us that student interest in these subjects is highest when in the elementary schools, and that by the time they are in junior high school many able students have lost much of their interest in science and mathematics (Yager & Penick, 1986). Appropriate instruction and learning opportunities can be provided for students as young as pre-Kindergarten, thereby allowing youngsters to grow up in a world of exciting, useful, and challenging math-and-science-related experiences. Adults raised under these conditions will be more likely to understand the fascinating and subtle aspects of science and math as human enterprises, leading to greater math/science interest, achievement, and appreciation.

The *Tao* reminds us too that, "The most difficult things in the world must be done while they are easy." Elementary students typically exhibit strong interest in suitably presented science and mathematics, thus offering a perfect opportunity for them to learn these subjects in a humanistic context. What I propose to do in this article is to make a case for presenting humanistic math and science to elementary school children, and then to introduce a theoretical, yet practical, framework for teaching these subjects in K-6 classrooms.

I refer to the subjects of math and science jointly in this article because, especially in pre-college educational settings the two can be, or should be, intimately linked. In the elementary classroom science and mathematics reinforce one another, each discipline drawing upon the techniques and tools of the other to offer students an experience and an awareness that is greater than the sum of the parts. Problem solving skills, whether in or out of school, will be strengthened when students can draw freely from the strategies of math and/or science as necessary. When these subjects are offered jointly students are able to make natural connections between math and science, enhancing comprehension and appreciation of both.

Imagine standing before a room full of thirty-two ten year olds. Now imagine that you are responsible for their understanding of mathematics and science, as well as other vital subjects including literacy, social studies, communication, collaboration/cooperation, and the arts. That is, imagine that you are an elementary school teacher. Next, consider how you will instruct these young students in this cornucopia of disciplines. Don't forget that those young people are potentially future graduate students in math and science, future workers at math/science related occupations, and perhaps even future teachers. Also, don't forget that as an elementary school teacher your academic background in math and science is probably marginal at best. Will you rely on the traditional textbook methodologies, or will you try the riskier and more demanding approach of action-oriented and individualized instruction? Imagine a curriculum that would motivate these students to reach high levels of achievement in math and science, while simultaneously encouraging their curiosity and personal interest. Imagine a curriculum that would lay the groundwork for a deep understanding of math and science as humanistic efforts. A great deal of educational research indicates that such goals are within our reach, and that they may be reached by our elementary-level students, working with motivated and inspiring teachers. (Drew, 1996; Myers & Fouts, 1992; Vargas-Gomez & Yager, 1987; Yager & Penick, 1986).

> **"**
> ***What sorts of experiences do they, the students, encounter in their lives?***
> ***What do they believe?***
> ***What do they want?***
> ***Who are they?***
> ***Who do they want to become?***

What should be the basic structure of a curriculum rich in humanistic aspects of math and science? A review of research regarding effective elementary pedagogy (Bruner, 1977; Dewey, 1926; Freire, 1970; Maslow, 1971; Rogers, 1983; Vygotsky, 1978; Yager & Lutz, 1995) suggests that a curriculum aimed at teaching the humanistic, aesthetic, and pragmatic aspects of science and mathematics should center on four theoretical and functionally interconnected components. Such a curriculum could apply to the teaching of math, of science, or of math/science. A humanistic curriculum would include *interactive/collaborative, holistic/relevant, interdisciplinary,* and *problem-based* components, each of which will now be considered at greater length.

INTERACTIVE/COLLABORATIVE COMPONENT

Elementary students, as fundamentally concrete thinkers, require a personal and interpersonal experience of humanistic math/science if we wish to offer them a deep and practical understanding of these subjects. Students must be actively involved in their explorations of scientific/mathematic phenomena. Engaging lessons that encourage personal involvement and provide opportunities for meaningful understanding are most satisfying and therefore optimally motivational for students. In action, this component will utilize what is known as "hands-on" or "minds-on" classroom activities, the former referring to explorations involving objects and materials actually manipulated by students (e.g., directing students to separate a large pile of various leaves into two piles, based on observable characteristics, then to construct a bar graph based on the piles), and the latter referring to activities that promote the use of higher order thinking skills, but not necessarily involving the use of materials by students (e.g., an inquiry demonstration presented by the teacher). These concepts are well described in the national standards now set for science and mathematics teaching (AAAS, 1993; NCTM, 1989; NRC, 1996) since they form the basis for the pedagogy described in those documents. These techniques are particularly crucial for marginalized, at-risk, and underachieving students.

Further, to be fully effective, interactive studies must be undertaken in a collaborative manner. Methods involving cooperative group work are essential to learning about science and math as humanistic endeavors. Not only is learning dependent on socialization (Vygotsky, 1978), but the basis of humanistic math and science lies in fostering an awareness of the interpersonal aspects of those disciplines. They cannot be taught in a social vacuum, i.e., simply reading about humanistic math and science is antithetical to developing authentic and functional comprehension and appreciation in these areas. A deeper understanding may be cultivated by actual problem solving in social settings and augmenting those experiences with media such as texts, videos, and computer-based learning.

HOLISTIC/RELEVANT COMPONENT

Closely associated with the Interactive/Collaborative Component is the need to present lessons that are relevant to the students themselves. Student-centered instruction focuses on student interests, student questions, student ideas, and student-generated projects. Humanistic math/science remains oxymoronic in a traditional classroom where teacher-centeredness is the rule. Memorization and retention of facts are not enough; a deeper understanding is required, which can only be accomplished through a process of scaffolding student learning from the familiar to the unfamiliar. The entire life of the child then becomes important to the humanistic educator. What sorts of experiences do they, the students, encounter in their lives? What do they believe? What do they want? Who are they? Who do they want to become? What do they like? What do they dislike? By taking a holistic view of the child, as opposed to limiting the curriculum to the cognitive dimension alone, the teacher may find numerous opportunities to creatively attach humanistic math and science to the child's daily experiences. Learning, founded on students' actual lives, can then build up and out in an ever-widening spiral.

The humanistic curriculum must also be holistic in the sense that it involves the entire child. Caring (Noddings, 1993), respecting, and empathizing (Rogers, 1983) are values that support students as unique thinking and feeling individuals in the process of growing and understanding the world. An ethic of care and compassion, openly and appropriately expressed, encourages their exploration of the unknown, both inside and outside the classroom. The teacher's style of interacting with students, in fact, has been shown to be a critical variable associated with student success in science and science-related classes (Ebenezer & Zoller, 1993; Eichinger, 1992, 1997; Myers & Fouts, 1992).

INTERDISCIPLINARY COMPONENT

Mathematics and science do not happen in a vacuum. They are composed of meaningful acts performed by real people in the courses of their lives. Just as I have recommended the blending of math and science throughout this article, these two subjects (traditionally treated as discrete entities in school) can also be combined effectively with other school disciplines. Interdisciplinary combinations not only promote the presentation of the subjects in a holistic and relevant context (as recommended above), but also provide opportunities for imaginative and personal connections between students and subject matter, which serve to further enhance understanding and motivation.

Examples of interdisciplinary strategies involving humanistic mathematics and/or science abound, combining art and mathematics (Hall, 1995; Reiner, 1994; Williams, 1995), art and science (Eichinger, 1996a; Kohl & Potter, 1993), art, mathematics, and science (Eichinger, 1997), music and mathematics (Huylebrouck, 1996; Kitts, 1996), chemistry and the dramatic arts (Budzinsky, 1995), literature and mathematics (Bernard, 1994; Growney, 1994; Lew, 1996), literature, art, and mathematics (Swetz, 1996), and history and mathematics (Priestley, 1996). Although not all of the aforementioned studies were written with elementary school teaching in mind, any of them could be modified to accommodate students in grades K-6. A servicable procedure for integrating units of study in elementary math and science was proposed by Francis and Underhill (1996). Examples of appropriately integrated math and science curriculum at the elementary school level include those by Curran-Everett (1997), who explores the properties of the Möbius Band, Scarnati (1996), who teaches observation techniques through the description and assembly of Lego shapes, and Eichinger (1996b), who challenges students to learn about thermodynamics through experimentation, data collection, and interpretation.

Other aspects of humanistic instruction that are often overlooked in traditional elementary settings, such as technological applications and the development of a critical social consciousness, are readily accessible through an interdisciplinary approach. The Science/Technology/Society movement (STS) is defined by Yager and Lutz (1995) as "the teaching and teaming of science in the context of human experience, including the technological applications of science" (p.30). STS instruction is therefore intimately tied to practical applications of mathematics and leads students to a deeply relevant understanding of the place of these subjects in their lives. STS techniques are empowering for students since, as stated by Yager and Lutz, "The richness of STS comes from contributions of the individual students, their creative ideas, and the central role they play in planning and carrying out the STS investigations" (p.35). Hurd (1994) called for a science/technology curriculum "that relates science to human affairs, the quality of life, and social progress" (p. 109), and whose "ultimate purposes are to have students who can take part in helping to plan the science/technology aspects of our sociocultural future" (p. 109). In this sense, notions of critical social consciousness, human rights, and social action may be forwarded in the elementary classroom through interdisciplinary humanistic instruction that includes authentic reflection and dialogue based upon real-world issues. In this way, the humanistic mathematics and science curriculum will "help students explore their personal and group identities relative to the social structures in which they live, others who live within the same social structures, the inequities that exist there, and students' roles in suffering from or benefiting from them" (Jennings & Eichinger, 1996, p. 12).

Another reason for encouraging an interdisciplinary facet to the humanistic curriculum is that it will provide teachers with more time to teach science and mathematics in a very busy curricular day. The accumulation of academic responsibilities, headed by the need to teach reading, writing, and mathematical calculation, leaves teachers too little time to explore other subjects in depth, especially if those subjects are taught in isolation from one another. In addition to providing opportunities for making meaningful connections to the other disciplines, the proposed interdisciplinary curriculum will create more space for teaching math/science in a humanistic context. Tie math/science into reading and writing. Connect it also with social studies, art, and physical education. Blend these subjects in new and innovative ways.

> "
> ***...students will understand and appreciate the value of math and science as humanistic endeavors only if they have used it to solve problems of interest to them.***

PROBLEM-BASED COMPONENT

The last of the four interrelated components refers to the importance of grounding the humanistic curriculum in meaningful, challenging problems and opportunities for authentic inquiry. Gone are the days when rote memorization of facts and algorithms suffice for a math/science education. An essential feature of the current standards in science and mathematics is a call for deeper, more active, and more relevant study of these subjects at all grades for all students. As stated by the National Research Council in the *National Science Education Standards* (1996), "Learning science [and/or math] is something students do, not something that is done to them" (p. 20). Posing realistic, interesting, and challenging problems for students or groups of students to solve is a mainstay of the current movement toward curriculum reform in math and science. The problem-solving instructional format has been associated with increases in student achievement and motivation at all school levels. Perhaps most importantly, students will understand and appreciate the value of math and science as humanistic endeavors only if they have used it to solve problems of interest *to them*. Through problem solving, students learn not only to effectively confront challenges in the classroom, but also to confidently face future choices and tasks presented by "real life," including those related to occupation, citizenship, leisure, and interpersonal relations.

Wheatley (1991) proposed a problem-centered model of mathematical and scientific learning designed to promote students' construction of subject matter knowledge in the classroom. That model is composed of three elements: 1) students are challenged with a task, 2) work is done in small groups, and 3) after working on the problem the groups convene to discuss their solutions. Group presentations are made to the class, not to the teacher, whose role is that of nonjudgmental and encouraging facilitator. The implications of the problem solving approach have been discussed by various authors, including Meier, Hovde, and Meier (1996) who stress the importance of "real life" and interdisciplinary applications, and Lipson (1995), who reported on student reactions to this sort of instruction.

A clear advantage of the problem-centered approach, as opposed to traditional, memory-based methods of instruction, is that it encourages the inclusion of more complex thinking skills. Critical thinking skills (e.g., analysis, synthesis, application, evaluation), metacognition (i.e., reflective thinking), and process-thinking skills (e.g., observing, predicting, inferring, questioning, experimenting, and communicating) are all a part of effective problem solving, and are also critical to an understanding of humanistic science and math.

A challenge presented by problem-centered instruction is that of assessment. Techniques of assessment and evaluation must be aligned with instruction, i.e., they must be congruent with the knowledge constructed by problem solving, rather than with traditional memory-centered pedagogy (i.e., testing for simple recall of facts and concepts). Problem-based learning necessitates assessment strategies that involve observation of actual student performance and solutions/products, and that note whether students can *apply and use* information.

THE PRACTICE OF TEACHING HUMANISTIC MATHEMATICS/ SCIENCE.

What does the humanistic curriculum look like in practice? Do programs exist that incorporate aspects of interaction/collaboration and holism/relevance within an interdisciplinary and problem-based instructional format? The good news is yes, there are some appropriate programs in existence. The bad news is that there are not enough such programs nor are they necessarily in wide enough use. Teachers, pressed for time to teach so many subjects in a school day, are likely to "overlook" subjects with which they are least familiar, and few are very familiar with dynamic and student-centered science and mathematics. Research shows us that teachers who are familiar with aspects of the humanistic style outlined above are more comfortable with the content and pedagogy of such a curriculum, and are therefore more likely to teach in a humanistic manner (Eichinger & Anderson, 1996).

Many classroom teachers employ their own uniquely designed humanistic curricula, but appropriate, larger scale programs do exist. Examples of instructional programs that tend to approach math and science in the four-pronged manner noted above can be found in the inquiry-based science/math curricula of Pasadena, CA, and Mesa, AZ, elementary schools. A number of packaged programs in math and/or science also offer options that approach an effective humanistic curriculum. Such programs include Project AIMS (Activities Integrating Mathematics and Science), Math Their Way, Full Option Science System (FOSS), Math Renaissance, GEMS (Great Explorations in Math and Science), and Mathland, among others. The professional journals *Teaching Children Mathematics* (formerly *The Arithmetic Teacher*), *School Science and Mathematics*, and *Science and Children* are also useful resources for the humanist elementary school teacher. Any curriculum package or program can be misused, however, and the best way to reach the greatest number of students is to be sure that the teachers themselves understand and appreciate the human aspect of math and science. Excellent instructional programs require excellent teachers, since, in the end, it is largely the teacher's expertise that determines the quality of the classroom experience.

Teachers, functioning as decision-making professionals and not merely as classroom "technicians," must be encouraged and supported in their pursuit of more effective humanistic instructional strategies. Viewing a popular movie such as *The Lost World: Jurassic Park* might stimulate a teacher to ask some interesting questions of her or his students. Just how big was *Tyrannosaurus rex*? Could we draw one in chalk on the playground asphalt? What color might it's skin have been? What makes you think so? Color in the skin with more chalk. Now let's estimate the volume of *T. rex* - how can we do that? How many ways can we think of to estimate its surface area, and which method is likely to be the most accurate? Could we build a scale model of *T. rex*? How big would a human be in comparison? How far do you think *T. rex* could jump, and how could you decide? Could it climb? Swim? What makes you think so? Can you find any evidence for your answers? What other questions do you have regarding *T. rex*? How could you find those answers? What resources are available to tell you more about *T. rex*? These sorts of investigations are based on the children's own interests, and combine math and science as tools to help young students discover what *they* want to know. Thus, math and science may be seen as relevant and useful *in their daily lives.*

Mathematics and science are not just topics in a book; they are interrelated elements of our everyday experiences as human beings. They can be living, exciting, and inspiring subjects when studied in a humanistic and relevant setting. What I envision is a time when children nationwide (dare I hope, worldwide?) will find a deeper connection to mathematics and science as humanistic pursuits. They may, for example, view broadcast images of math/science in action such as the travels of the Mars Rover Sojourner, exclaiming with enthusiasm and joy, "That looks like what we did in school!" To accomplish this goal, we can't afford to wait until these students enter college. We must act on the knowledge that "...the greatest things in the world must be done while they are small."

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The Legend of the Apple

Raul A. Simon
Departamento de Pisica, Universidad de Tarapaca
Casilla 27-D, Arica CHILE

Slowly darkens the English countryside;
pale and distant, the moon sails the sky,
announcing to the green and sleepy farms
the coming of a new warm summer night.
Silent and brooding, the young scholar sits
close to the door of his ancestral manor,
and in the melancholy, timeless peace
surrounding him, his mind leisurely wanders
into half-closed domains of time and space.

Behold. One of the savory red fruits
noisily falls down from an apple tree,
compelled by its own sweet maturity.
The truth-searcher, lifting his idle gaze,
beholds both fallen fruit and silv'ry disk,
and the sharp edge of cruel inner lightning
pierces in silence the young scholar's brain:
Is it then possible that star and fruit
obey one law, both cases being one?
(Why does satellite not fall to earth,
but instead, far into the past and future,
once and again follow dutiful ellipse?)

Before dawn comes, will Isaac Newton find
the law of gravitation in his mind.