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AN AESTHETIC APPROACH TO THE TEACHING OF SCIENCE

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Abstract

The role of aesthetic curiosity in the manipulation of materials is often ignored or considered irrelevant in most science curricula. Contemporary practice in curriculum design emphasizes an approach that views science and art as separate types of explorations. Some historians of technology and science suggest that basic discoveries arise out of an aesthetic curiosity fostered by play with materials or ideas. Experience with certain familiar materials of aesthetic interest suggest that children will sustain play for long periods and easily mix metaphors of art and science in developing an understanding of the phenomena that are a part of the experience. Several examples are given of how this might be accomplished.

Introduction

Very often in science curriculum design the aesthetic impact and its related emotional engagement are generally ignored. It has been my experience working with children that they are more interested in what can be done with materials than what can be learned from them. A child does not roll marbles down a track and have them collide with each other to find out about Newton's laws of motion. He or she is more interested in what kind of effect can be produced. Also, the tangible concrete properties are more likely to elicit role playing or projection of personal emotions than an explicit attempt to gain cognitive control of the situation or to understand an abstract concept.

This tendency to be attracted to the aesthetic properties of materials and to explore through fantasy play is a manifestation of a basic need of man, i.e., a need to play. It is also a manifestation of the root of a great deal of exploration that is closely intertwined with play. Aesthetic and epistemic curiosity—a fundamental part of man's drive to understand the world—are not sufficiently acknowledged in education.

The Role of Aesthetic Curiosity in the Development of Science and Technology

Emphasizing the aesthetic and concrete properties of materials may run counter to today's conceptions of what science involves, but there is historical and anthropological evidence that this was not always the case. What some scholars have to say concerning this is not only relevant to our understanding of the history of science, but also of great importance, in how we initiate children and even adults into what we call science.

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Cyril Stanley Smith, who was trained as a metallurgist but in later years became a historian of technology, came to some rather interesting conclusions after researching artifacts of Western and Eastern antiquities and the context in which they were fabricated.

> Historically the first discovery of useful materials, machines, or processes has almost always been in the decorative arts, and was not done for a perceived practical purpose. Necessity is not the mother of invention—only of improvement. A man desperately in search of a weapon or food is in no mood for discovery, he can only exploit what is already known to exist. Discovery requires aesthetically-motivated curiosity, not logic—for new things can acquire validity only by interaction in an environment that has yet to be. (Smith, 1976)

> Later in this article he cites some examples to illustrate this point:

> The wheel first appeared on toys, the automata based on hydraulic and mechanical tricks that were used in Greek temples and theatres foreshadowed the water wheel and the clock. The lathe reached an apex of ingenuity in turning quilloche snuff boxes a century before heavy industry used it, and rockets for fun came before their military use or space travel.

Coming at this question from an anthropological perspective is Claude Levi Strauss, in his book *The Savage Mind* (1966). The entire first chapter examines what he calls the "Science of the Concrete." In it he makes an important distinction very relevant to the teaching of science to children.

> Neolithic, or early historical man was therefore the heir of a long scientific tradition. However, had he, as well as all his predecessors, been inspired by exactly the same spirit as that of our own time, it would be impossible to understand how he could have come to a halt and how several thousand years of stagnation have intervened between the neolithic revolution and modern science like a level plain between ascents. There is only one solution to the paradox, namely, that there are *two distinct modes of scientific thought.* These are certainly not a function of different stages of development of the human mind but rather of two strategic levels at which nature is accessible to scientific enquiry: one roughly adapted to that of perception and the imagination: the other at a remote from it. It is as if the necessary connections which are the object of all science, neolithic or modern, could be arrived at by two different routes, one very close to, and the other more remote from, sensible intuition.

> Any classification is superior to chaos and even a classification at the level of sensible properties is a step towards rational ordering. It is legitimate, in classifying fruits into relatively heavy and relatively light, to begin by separating the apples from the pears even though shape, colour, and taste are unconnected with weight and volume. This is because the larger apples are easier to distinguish from the smaller if the apples are not still mixed with fruit of different features. This example already shows that classification has its advantages even at the level of aesthetic perception.

Criteria invoking the aesthetic is not limited only to the concrete level in science. In recent years there have been some historians of science and scientists who have themselves pointed out the influence a sense of form and aesthetics has on the manner in which theoricians formulate their theories, even in those disciplines called hard sciences. Among recent books and articles which have dealt with this topic are Wechsler's *On Aesthetics in Science* (1978), Koestler's *Act of Creation* (1964), Chandrasekhar's Beauty and the Quest for Beauty in Science (1978), and J. M. Eklund Art Opens Way for Science (1978), as well as a number of essays in Kepes's series Education of Vision (1966). In the assembled essays of Wechsler's book and in Chandrasekhar's essay the great nineteenth and twentieth century mathematicians and physicists are quoted. Bohr, Poincaré, Weyl, Hisenberg, Dirac, and Einstein, as well as others express their need and trust in their sense of aesthetic order in shaping their formulations.

What is gradually being recognized is that at a deep level the scientist and the artist tap into the same sources for their creativity. Intuition and the interplay of the senses is so strongly associated with art that by definition it seems that they are excluded from the sciences. Comments from the above scientists give evidence to the contrary.

Indeed, there are great differences in what the artist and the scientist think about, how they proceed, and the products that result, but underlying all of this is a search for beauty and simplicity.

Intrinsically Interesting Materials

Experience in formal and nonformal settings watching children explore with a variety of materials has led me to the conclusion that certain materials are more evocative than others. One of the most engaging is soap film and bubbles. Whether it was presented to preschoolers, college students, or senior citizens, I found that there was great fascination in making and watching various kinds of bubble arrangements. There was no need to motivate them to explore the properties of the soap film. By introducing new devices that revealed different aspects of soap bubbles, I found that children's interest was sustained for days.

Bubbles, spinning tops, rolling marbles down tracks are what I would call intrinsically interesting phenomena. They are hypnotic in their engagement with the activator. It is as if they trip off a neurophysiological reaction in the individual. More than the visual and the tactile are involved, the haptic sense in Gibson's definition of the term is also actively engaged. The properties also give rise to an emotional involvement and thereby offer possibility for aesthetic expression. Given the open-ended nature of these materials and their accompanying reactions, they are good media for the artist, and full of opportunities for learning basic physical science concepts.

The Contemporary Artist's Choice of Materials

Within the Western tradition of art, especially that which has been called the "fine arts," the major media for painters and sculpture have been oil paints, canvas, metal and stone. Since the turn of the century, there has been a revolution in the form, content, and range of materials used by the "serious artist." Nowadays, it is no longer unusual to visit art gallerys and find ropes hanging from walls, crushed automobiles, plastic constructions, spinning wheels, or such ephemeral phenomena as soap film. As artists have extended the media in which they work to include almost any kind of material, the establishment's notion of art has been broadened.

Artistic expression can be just as valid with the use of tin cans as with cast bronze. What follows this I think has implications for the science educator. Rolling marbles along a track may seem to be mere play having no external references beyond the activity itself. However, to the contemporary artist it offers possibilities for the making of a variety of kinetic sculptures. In fact, one such sculpture is part of an exhibit at the Children's Museum in Washington. To the physical scientist the same kind of situation presents concrete models for developing an understanding of the science of kinematics, as evidenced by the number of devices using ball bearings in the PSSC program and other physics curricula. Depending upon the kind of metaphor that one brings to a material there exists the possibility for artistic expression or for scientific elaboration.

Discovering the Nature of Materials

Even though there have been great changes in art during this century, some fundamentals with regard to the working of materials remain the same for the artist. Among the traditional crafts, people both in the West and in societies around the world have expressed in various ways an ethic regarding the nature of how one works with materials. A similar sentiment has been expressed by some artists of this century. The best description of what I mean by this was given by Edmund Carpenter (1966) in describing how the Eskimo carver approaches the carving of ivory or bone.

> As the carver holds the unworked ivory lightly in his hand, turning it this way and that, he whispers, "Who are you? Who hides there?" And then: "Ah, Seal!" He rarely sets out to carve, say, a seal, but picks up the ivory examines it to find its hidden form and, if that is not immediately apparent, carves aimlessly until he sees it, humming or chanting as he works. Then he brings it out: seal, hidden, emerges. It was always there: He did not create it. He released it: He helped it step forth.

Albert Elsen in his book, *Origins of Modern Sculpture* (1979) indicates that a similar sentiment held sway among artists, especially sculptors at the turn of the century.

> A premise frequently ascribed to the early period of modern sculpture is that the artist must be true to his material. He must respect the intrinsic qualities of the medium so that the viewer will be aware of the appropriateness of the image to the substance that has given it form.

This concept of fidelity to the medium may be acknowledged by art educators but such a sentiment has not been consciously kept in mind by the designers of science curriculum. Since the emphasis is on the development of logical thinking or the grasp of abstract scientific concepts, materials and experience are chosen to illustrate or demonstrate such concepts or processes. This approach differs from one where the concepts emerge through play and exploration of a material.

Implementation of an Aesthetic Approach

Having established some general criteria for an aesthetic approach to the teaching of science, how would this be translated into practical results? As already mentioned, my experence has indicated that there are some materials and phenomena that are more evocative than others in terms of involving children in an exploratory and playful mode. This does not mean that a curriculum should only be limited to the intrinsically interesting materials. Rather, they can act as model experiences to guide us in exploiting other materials that are not as open ended or as evocative.

Bubbles and soap film are examples of a phenomenon that is both aesthetically captivating and revealing of scientific concepts. The colors, forms, movement of the film possess a very sensuous quality, thoroughly engaging anyone that starts playing with them. Part of the aesthetic appeal of the shapes is that there are variations within similarities, i.e., the same general types of shapes continually occur but they are never exactly alike.

Bubbles are considered so frivolous by some educators that they are seldom explored in schools. If they are mentioned it is usually in the context of demonstrating surface tension. In my experience I have found that even adults have trouble understanding this concept. Soap film is excellent for demonstrating such phenomena, but there are obvious characteristics of bubbles that are more accessible to beginners in science. If you blow bubbles on a table top with a drinking straw, you find that they always join together in a certain fashion and that no matter how hard you try they will not form squares or cubes. What emerges from a dialogue with bubbles in this context is that they prefer to join in a very definite arrangement. In two dimensions you always get three film joinings at an intersection. In three dimensions the observer will find that they most often join together in a geometric shape having 12 as an average number of sides.

As pointed out by D'Arcy Thompson (1961) and further elaborated upon by Cyril Stanley Smith (1958) and Peter Pearce (1978), bubble arrays can be considered archetypes of structural systems both large and small. When placed in certain kinds of frameworks, bubbles will imitate the arrangement of cells in dragon fly wings or the structure of the Radiolarium. Architects such as Pearce are building generic structures based on the way bubbles congregate.

What is present here is something that is both emotionally and intellectually satisfying. There is a resonance between the emotional and the intellectual domains. An abstract geometry of structural relationships has its roots in an aesthetically pleasing colorful phenomenom of soap film. In carrying out an aesthetic approach to the teaching of science I have developed a set of criteria for choosing materials, and a process by which they are presented to children. First, materials or phenomena that are intrinsically interesting are chosen because experience has indicated that they have widespread appeal. Given the right kind of social and physical environment, children will easily become engaged in investigating these materials, i.e., the materials, not the teachers, are the motivators. Second, the materials are of immediate aesthetic interest, allowing the child to manipulate the forms and to project his or her own personal experiences and emotions. Thirdly, there is a variation of a potential theme that is embedded in certain significant properties of the materials. The theme acting as an organizer can be either a general or specific concept from the physical sciences and is a means for having the abstract emerge from the concrete.

Role of Play in Learning Science

Essentially, what I am advocating is that play be encouraged more in the teaching of science. Science among science educators seems to be very serious business, and it appears that they feel it should be presented that way. One does encounter the occasional teacher who tries to present it in a fun way but they seem to be a minority. Witness the folowing comment by J. Richard Suchman (1977) in a speech to the National Association for Research in Science Teaching.

> It may sound insane to say this, but teachers and students need to be encouraged to play, to go crazy and to be irrelevant. Play is a creative process.

The rest of his speech makes some very interesting and significant points about heuristic learning, very much related to what has been presented in this article. Yet, he feels that he has to apologize for mentioning play.

As Schiller has written, man is only human when he plays. If educators are to design an educational experience that addresses the child as a whole human being rather than a learning machine or computer, then they need to recognize not only the importance of play at all levels of learning, but also let it flourish in all kinds of educational situations. At a deep level art and science are ultimately embedded in play and through some subtle and strange ways connected to each other. To preserve and foster this connection, we need to recognize the aesthetic that is in science and the science that is in art.

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