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ABSTRACT

Numerous scientific concepts and principles underlie the operation of all manufactured products. Increasingly, teachers and science educators are coming to realize that students need more investigative "hands-on" activities and they need to see some rather immediate relevancy of what they are studying if they are to study science with enthusiasm. In response to these concerns, many lessons and units in science, technology, and society (S/T/S) can be organized around such life problems as food-getting, clothing, shelter, transportation, and communication and initiated by the investigation of human-made objects. The features that such a lesson would incorporate include the following: (1) shop and laboratory facilities; (2) teaming of teachers; (3) interdisciplinary subject matter; (4) investigating learning activities; and (5) cooperative learning. (KR)

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BEGIN WITH THE NUTS & BOLTS OF S/T/S

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BEGIN WITH THE NUTS & BOLTS OF S/T/S

If dissecting frogs is a legitimate approach to biology why can't dissecting or dismantling all sorts of common things such as washing machines and bicycles be used to introduce other subjects? Many of us have an urge to take things apart to find out how they work. Putting them back together again can reinforce understanding. Numerous scientific concepts and principles underlie the operation of all manufactured products. Increasingly, teachers and science educators are coming to realize that students need more investigative "hands-on" activities and they need to see some rather immediate relevancy of what they are studying if they are to go at it with enthusiasm. Certainly more enthusiasm for science is needed.

Few will disagree that changes are needed in American science education. The structure-of-the-academic-disciplines and textbook approaches of the '60s, '70s and '80s have failed to turn a majority of students on to science. Consequently new goals and curricular patterns are being advocated. As early as 1981 the NSTA Project Synthesis report emphasized goal clusters that focused on personal needs of students, societal issues and career awareness in addition to academic preparation. More recently, the authors of the Project 2061 report, Science for All Americans (1989), sponsored by the AAAS, highlighted "Scientific literacy - which embraces science, mathematics and technology" as a central goal for education. Others have advocated the infusion of environmental concerns throughout the curriculum. Early progress reports on NSTA"s Project on Scope, Sequence, and Coordination of Secondary School Science emphasized the motivational value of science lessons that eminate from personal and societal problems and practical applications.

In response to these concerns I suggest that many science lessons and units can be organized around such life-problems as food-getting, clothing, shelter, transportation, and communication and initiated by the investigation of the human-made objects that surround us. In such units students would first observe the objects in their normal settings and note structures and functions of the object and its parts. Then some would be dismantled as certain key questions are pursued that lead to an understanding of their over-all operation, the industrial processes that produced them, the nature of their constituent materials, their social, economic and environmental significance as well as the scientific principles governing their operation. Some objects could be repaired and reassembled or reconstituted in other ways. For example, the electrical system of a washing machine could be assembled on a table top to show how the timer operates switches that control solenoids attached to valves that turn hot and cold water on and off at appropriate times.

An additional activity would be to have students design and construct objects to meet certain criteria. For example, a common activity now is to have a contest to see who can construct the strongest bridge or tower from a given number of soda straws or toothpicks. The focus in these new units however, would be on the mechanical principles employed in the design and not just on trial and error approaches.

These technological investigations would give rise to questions that would establish the need for more focused instruction in basic science, mathematics and social studies. Unlike traditional approaches in which students are presented with science as it appears in the disciplines, students would begin with the reality that is close to them and then progress through the curriculum gradually reconstructing their experiences to formulate their knowledge at higher levels of abstraction and generality. This, after all, is what scientists themselves, have always done. The artificial nature of schooling has been that we too often have tried to spoon feed science-the-final-product to students whether they were ready for it or not. Unfortunately highly verbal students have been able to fool us by memorizing the right vocabulary and getting high test scores. Others, a bit more honest perhaps, in their rejection of the traditional, have come to be known as "at-risk" students. Few at either extreme or anywhere in between develop a good functional understanding of natural phenomena or the human enterprise of science that produced this knowledge.

A program which employs this investigative approach would have these features:

A. Shop and laboratory facilities with appopriate tools in sufficient quantities for students to work individually or in small groups. Some of the lessons might have to be conducted in the industrial technology or home economics areas rather than the science laboratory.

B. Teaming of teachers having differing specialties. Industrial technology teachers are usually best equipped to help students acquire proper skills with tools and develop an understanding of industrial processes. (How many science fair projects have we seen which exhibit good science but poor workmanship with materials?) Science teachers are needed to help students find underlying concepts and principles and organize them in a manner that leads to long- range curricular goals. Certain topics could require the involvement of other teachers to help the team see how these investigations relate to their subjects.

C. Interdisciplinary subject matter. The problems of the world do not present themselves to us in the way that scholars have organized their separate disciplines. Therefore, school work should be more comprehensible to students if it is initially organized around artifacts used to deal with common practical problems.

This sequencing of subject matter from life-problems to the more familiar basics can be a trend withing individual lessons, month-long units, year-long courses and throughout the K-12 curriculum. Of course, this approach may not be appropriate or possible for certain topics so it is not offered as a universal formula.

A fully elaborated program of this sort would amount to a core curriculum. However, one does not have to uproot an entire school program to begin teaching science, technology and society (S/T/S). Teachers and students in one science class could gather the necessary tools and artifacts and work within the confines of the existing class schedule.

D. Investigative learning activities. The purpose is not to present students with myriads of information about the technology of familiar objects. Rather, it is to have students investigate these objects with minimal teacher guidance to obtain data which, with increased teacher support and more traditional learning experiences, will lead them to an understanding of how the abstractions of science, mathematics and social studies are grounded in the commonplace. The investigation of technological artifacts is really the exploratory phase of a learning cycle. Following this would be the concept introduction and concept application phases.

This investigative approach can be used at all grade levels and in all science areas provided the artifacts that are examined and level of sophistication of the exploration is appropriate for the students. In the elementary school toys, playground equipment, small appliances, flashlights, skateboards, tricycles, bicycles, sleds, articles of clothing and even food items such as cookies and breakfast cereal can be used. Older students can dismantle or analyze washing machines, dryers, vacuum cleaners, lawnmowers, furniture, clothing, and cooked items. A major activity would be the dismantling of an automobile in the senior high school. Think of all the systems and subsystems in an auto including electrical, suspension, hydraulic, fuel, exhaust, drive train, passenger safety and even accoustical in newer cars.

In all cases student attention would first be directed to the practical aspects of the artifact. Listed below are examples of questions that would lead students through these learning sequences. Hopefully many of these can be elicited from students themselves through orienting discussions that begin with consideration of some artifact.

1. What function does this item serve?
2. Why is it structured in the way that it is?
3. What alternate forms could it have?
4. Describe its over-all structure and identify substructures and/or systems of structures.
5. Of what materials are the parts made? Why were these materials used? What are their properties?
6. Where did these materials originate?
7. How were they extracted from their sources?

8. What were the environmental impacts of these extraction processes?
9. How were the materials processed and transported from their sources to the sites at which they were incorporated into the final product?
10. What processes were used in the manufacture of the artifact and what was their environmental impact?
11. When the object is worn out or no longer needed, how will it be disposed of and what will be the environmental impact of this disposal process?
12. What energy sources and forms are used in the manufacture, use and disposal of this item?
13. What scientific principles and concepts are used to explain the functions of the artifact and its parts?
14. How have artifacts serving the same purposes changed since their original invention? (Then, how do the answers to questions 1 - 13 change during this period?)

In any single life-problem topic many basic sciences might apply. This should not be a concern. For many children it probably is more meaningful to organize subject matter in terms of life-problems than in terms of the traditional disciplines. In addition to learning the answers to questions about particular artifacts students will learn skills with tools and technical procedures necessary for dismantling and reassembling them. Many of the questions lead to library research, to consultations with resource persons in the community and perhaps to correspondence with manufacturers.

E. <u>Cooperative Learning</u>. These many problem solving activities lend themselves readily to cooperative group work since it is unlikely that there would be time or opportunity for each student to pursue all of the questions. Furthermore, each investigation would involve activities of varying levels of difficulty which makes this approach ideal for adapting instruction to students having differing interests and abilities.

To get started with a life-problem unit choose the topic and consider your objectives. Consider how this unit will contribute to your over-all goals for the year. What are the concepts, principles, skills and attitudes that you want the students to learn? Consider all the artifacts that can be obtained for this study; visualize the students exploring them and try to anticipate all the learning outcomes that will actually occur. What safety problems might arise?

About this time begin to collect the artifacts. Usually these will be broken or worn-out item that can be donated by students, teachers and merchants. Different models of certain items may show up so it is a good idea to enlist the aid of a dealer who could supply service manuals for the items. These would normally be for your benefit since it is the students and not the teacher who should be making the discoveries in class. This planning process should involve your dismantling of sample items privately to identify the basic concepts that should be dealt with in focused science lessons and to anticipate learning difficulties and safety problems. Given differences among pupils, different expectations may have to be established and provided for.

A site for storage of these items will be needed when they arrive. Storage space will also be needed for the incomplete dissections when the unit is underway. A site and sufficient tools will be required for the student activity itself. This could be a school shop, science laboratory or a classroom with table space.

Ideally, an instructional team will be formed so that teachers and outside resource persons having different areas of expertise will be involved. Each will have a different role and this should be clarified as much as possible before instruction begins.

Finally, sources of information about the artifacts and the whole life-problem area they represent must be identified. Librarians and community resource person will be helpful. Textbooks will be of greater use when it comes to instruction in the related basic subject matter even though its organization in the unit may differ from that in the text.

This down-to-earth approach to the interdisciplinary subject matter of S/T/S will take planning and practice because there is no textbook to follow and many things will be happening at the same time in the investigative classroom. There will be a price for this but the rewards should be increased motivation for science and other subjects whose relevance to daily affairs of the students is no longer obscure.