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AUTHOR Karian, Michael E.
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ABSTRACT

This paper provides a starting point for the systematic design of instruction to integrate environmental education content curricula-wide. In order to facilitate the integration of environmental education into technology programs in particular, the paper addresses each of the following associated issues: (1) lack of agreement as to the relative importance and location in the curriculum of such content (i.e., where it should be taught); (2) lack of clearly established course/program outcome objectives related to environmental education (i.e., what should be taught); and (3) insufficient teacher experience in instructional design to facilitate integration of such content (i.e., how it should be taught). A sample procedure for the design of instruction focuses on the use of task analysis theory. Contains 27 references. (LZ)

CURRICULUM AND INSTRUCTIONAL DESIGN FOR THE INTEGRATION OF ENVIRONMENTAL EDUCATION

Dr. Michael E. Karian
College of Science and Technology
St. Cloud State University
St. Cloud, MN 56301
(612) 255-3966

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CONTENTS

Introduction

The importance of addressing environmental issues in education has been widely accepted by numerous authors throughout education (e.g., Boyer, 1983; Disinger, 1985/86, Hammerman & Voelker, 1987; Hungerford, Peyton, & Wilke, 1980; Volk, Hungerford, & Tomera, 1984; National Commission on Excellence in Education, 1983; Yager, 1984). A current problem is that despite the importance of this topic, there is a lack of focus for its study and a failure to agree upon guidelines and learner outcomes for curriculum and instruction efforts in this area. As a result, educators are often not provided sufficient guidance to integrate environmental education.

In order to facilitate the integration of environmental education into technology programs in particular, this paper will address each of the following associated issues: 1. Lack of agreement as to the relative importance and location in the curriculum of such content (i.e., where it should be taught), 2. Lack of clearly established course/program outcome objectives related to environmental education (i.e., what should be taught), and 3. Insufficient teacher experience in instructional design to facilitate integration of such content (i.e., how it should be taught).

Curriculum Integration (Where)

One major issue to be addressed in the integration of environmental education is where the appropriate material should be taught. In fact, there has been significant disagreement over the years as to the placement of such material. In this paper, however, the specific application of concern is integration into technology programs. That topic is discussed in the following section.

Technology and Environmental Education

Many authors (DeVore, 1980; Jump, 1985; Karian, 1987; Lauda, 1984) have suggested that because the application of technology is that human endeavor that impacts the environment more than any other such endeavor, environmental issues should be addressed within technology education. Baez (1987) even went as far as to say that it is "the task of . . . technology education . . . to invent new ways in which the concepts of ecology, which lie at the heart of environmental education, can be infused into education as a whole and into . . . technology education in particular" (p.10).

According to this view, addressing environmental concerns out of the context of technology does not provide students with the complete environmental picture. Furthermore, the call for incorporation of environmental education within technology education has been deemed necessary for a complete understanding of the nature of technology. DeVore substantiated this in 1980: "If the true nature of technology is to be determined, then it must be studied in the context of technical systems and their relationship to . . . ecological systems" (p.253).

This approach was also supported by Karian in 1987. He claimed that "an understanding of how technology affects the environment is an essential component to understanding technology as a broad concept" (p.14). Jump (1985) voiced a similar opinion when he stated that "to exist successfully in the world of tomorrow, the technology students of today must understand the . . .

environmental changes wrought by technology" (p.3).

Additionally, many technology educators (Bensen, 1986; Hales & Snyder, 1982; Savage & Morris, 1985; Technology Education Advisory Council [TEAC], 1988) have proposed curriculum models that include the study of environmental topics. In 1982, participants of the Jacksons' Mill Industrial Arts Curriculum Theory Conference concluded that "technology . . . requires vast amounts of natural resources . . . which raises value questions that can only be answered realistically by an educated populace" (Hales & Snyder, 1982, p.22).

Another curriculum model that was inclusive of environmental issues was developed by Savage and Morris in 1985. They concluded that "the environment in which we live and work is critical for survival. Technology must provide safe surroundings for its workers while protecting the world's environment" (p.8).

The Technology Education Advisory Council (1988) also presented a conceptualization of Technology Education inclusive of environmental topics. The Council concluded that technology, society, and values make up three "self-consistent planes of notions that intersect in myriad ways [and] . . . technology cannot be viewed apart from its interactions with society" (p.5). In this conceptualization, environmental issues associated with technology are included under the society plane.

<u>Curriculum Guidelines, Sequencing, and Approaches</u>

Clearly a rationale has been established for the integration of environmental education into technology curricula. In order to determine appropriateness for specific situations, however, local curricula initiatives and guidelines must be considered.

This will necessarily include a formal analysis of such things as required credits for graduation; State, District, or Administrative Initiates and Guidelines; and content overlap between courses and programs. Such analysis should also involve the systematic planning of curriculum organization to address content sequencing. In other words, the sequencing of various outcomes, units, and courses must be organized successively so as to provide the student a meaningful learning experience throughout the curriculum. Once this has been done, instruction can be planned.

Informal curriculum guidelines, on the other hand, are political and procedural issues that influence the curriculum revision process indirectly, but nevertheless must be considered if integration is to be successful. Examples include resistance to change, departmentalism, or lengthy curriculum revision procedures that might inhibit the integration process.

The curricular **approach** to integration must also be considered. Environmental education content could be infused into existing course content, offered as separate units within courses, or make up completely separate courses. Another approach would be to develop and integrate comprehensive environmental programs as an addition to current offerings.

Determination of Outcomes (What)

A second major question to be answered in planning the integration of environmental education programs involves the determination and selection of learner outcome objectives. Westphal and Westley (1985/86) spoke to this need by declaring that:

it is always difficult to determine the educational benefits and environmental impacts of a program . . . However, providing goals and objectives that can be quantitatively assessed is the first step toward improving the content of environmental education programs. (p. 29-31)

Preliminary Literature-Generated Outcomes

A comprehensive study undertaken by Karian (1991) provided the first comprehensive national list of learner outcomes addressing environmental issues in technology education at the secondary level (reported in Karian & Stahl, 1992). The study identified and verified a preliminary list of 39 outcomes based upon highest level of endorsement and lowest level of variation among respondents. Those objectives can serve as a starting point to begin the design of instruction to address environmental issues in various technology curricula nationwide. Those objectives are listed in Table 1 in descending order of importance.

Appropriateness and Limitations

Determination of appropriate outcomes for specific applications, then, requires at least the following two steps: 1. review of the previous list to determine the relevance of each outcome, and 2. addition of any additional outcomes that are not included on the previous list, but are nevertheless deemed important for that application. In this way, a list of instructional outcomes appropriate for any given situation can be readily compiled. Selection of appropriate outcomes will necessarily depend upon an analysis of limitations such as the priority of any other (primary) outcomes, classroom time, instructor expertise, instructor time, and availability of funding, among others.

Table 1
Nationally Verified Student Outcome Objectives for Environmental Education Integration

THE STUDENT WILL BE ABLE TO:

1. State the need/value of being "technologically literate."

2. State the need for individual responsibility in present and future maintenance/improvement of environmental quality.

3. Explain the responsibility humans have toward the environment.

4. Describe the ways technology is becoming increasingly important in their lives.

5. Describe a number of roles technology plays/is likely to play in shaping the future.

6. State the need for societal responsibility in present and future maintenance/improvement of the environment.

7. Describe environmental issues/problems related to technology.

8. Explain the effects of the advancement of technology on the environment.

9. Describe conflicts of interest in the use of earth's resources.

10. Describe the concept of technology, including basic technological principles, evolution, nature and utilization.

11. Evaluate the pluses and minuses of human uses of technology.

12. Locate sources of information regarding technology and technological impacts.

13. Describe the significance of technology in regard to environmental impacts.

14. Describe present and likely future environmental changes brought about by uses of technology.

Table 1 - Cont.

15. Describe the effects of environmental degradation on likely further technological development.

16. Describe the total environment within a holistic view (systems approach).

17. Describe human technological actions toward and behaviors in the environment.

18. Describe future prospects in regard to environmental impacts of technology.

19. Describe past and likely future changes in the environment associated with human application of technology.

20. Evaluate environmental aims and possible solutions in regard to the consequences of technological impact.

21. Describe potential ecologically sound technological applications.

22. Analyze issues relevant to the environmental impacts of technology.

23. Apply technological principles to problems and issues associated with the environment.

24. State possible solutions to and methods of solving environmental problems.

25. Explain the relationship between environmental changes and cultural, social, economic, and political decisions and actions.

26. State his/her personal values/behavior toward technology and the environment.

27. Critique the effects of technological decisions on the environment.

Table 1 - Cont.

28. Describe relevant specific environmental issues related to technology.

29. Apply tools, materials and processes associated with technology safely and efficiently.

30. Apply the procedures involved in the processes of invention/ innovation.

31. Describe how humans fit as an inseparable part of the global environment.

32. Describe humanity's place and relationship within the global environment.

33. Describe likely forces that influence human decisions and actions in the future.

34. Investigate environmental issues and possible solutions.

35. Explain scarcity of resources and societal resource allocation methods.

36. Integrate technical and social aspects of environmental problems.

37. Demonstrate action strategy skills directed at participation in improvement/protection of the environment.

38. Describe alternative solutions to environmental issues.

39. State the need for governmental responsibility in present and future maintenance/improvement of the environment.

Design of Instruction (How)

Having addressed the where and what of integrating environmental education, the third major question to be answered is how to design and deliver instruction so that students can attain the chosen outcome(s). As Gagné (1977) maintained:

> Once the [outcome] objectives of a unit or course of study have been defined . . . the design of a plan for instruction is on firm ground. The aims of the instruction (the "what" to teach), however large or small, are at that point unambiguously determined. In proceeding with systematic instructional design, the next major stage to be completed is to determine the means of instruction, the "how" to teach. (p.115)

Task Analysis

Despite the variety of instructional design theories and models available in the literature, for the purpose of demonstrating instructional design procedures associated with the integration of environmental education, those procedures prescribed by task analysis theory has been applied. According to that theory, there are three possible components to the design of instruction:

> 1. **Information processing analysis** of the human performance, to reveal its sequence of mental operations.
>
> 2. **Task classification**, categorizing the type of learning outcome represented by the task (or a collection of tasks), as a means of identifying necessary conditions for learning.
>
> 3. **Learning task analysis** of the performance and its mental operations, to reveal the prerequisites of learning and desirable sequencing of learning events. (Gagné, 1977, p.115)

Following are expanded descriptions of each of these components.

Information processing analysis. The first component of task analysis, information processing, consists of analyzing the outcome objective to determine the procedural characteristics, or mental operations that comprise the performance. These procedures may be overt behavior, or cognitive operations internal to the learner. Gagné summarized the usefulness of this type of analysis in 1977: "when single instructional objectives are analyzed in this way, it is in recognition of their characteristics as **procedures**. That is to say, the nature of the learned capability that makes possible the desired performance is a **procedural rule** (p.118).

Not all outcome objectives are attained by procedural rules, however, and therefore information processing analysis is not always conducted. According to Gagné, "many skills, both intellectual and motor, have this characteristic, although not all do" (p.118).

Task classification. The second component of task analysis consists of classifying each outcome objective to one of five categories of learned capabilities on the basis of the type of learning involved. Classification of the outcome must precede the learning analysis. As Gagné (1985) suggested:

> Proper usage of the principles of learning to achieve effectiveness of outcome requires, first, that the class of learning outcome be identified for any specific learning task that the learner undertakes. Once this is done, steps can be taken to discover what internal conditions are applicable to the learning task, and further, to arrange the external conditions so that the expected outcome will be

achieved. (p.259)

For the purpose of classifying learner outcome objectives, task analysis theory prescribes five major categories of human capabilities, or learning outcomes. They are: (a) verbal information, (b) intellectual skills, (c) cognitive strategies, (d) attitudes, and (e) motor skills (Aronson & Briggs, 1983; Gagné, 1977, 1985; Gagné & Driscoll, 1988; Petry et al., 1987). As Gagné (1965) revealed, "each of these forms of behavior carries a different implication regarding the conditions of learning needed for its establishment" (p.60). A brief definition of each category is presented below:

1. **Verbal Information** -- Stating propositions (names, facts, connected sentences) in terms of their meaning.

2. **Intellectual Skill** -- Demonstrating the application of regular symbolic relationships to specific instances.

3. **Cognitive Strategy** -- Controlling or modifying the learner's internal processes of learning and thinking.

4. **Attitude** -- Choosing a course of personal action towards some object, person, or event.

5. **Motor Skill** -- executing muscular movements coordinated to the achievement of some goal or product, and characterized by smoothness and precise timing. (Gagné, 1977, p.126-127)

The second category of learning outcomes, intellectual skills, is composed of five sub-categories. As revealed by Gagné and Driscoll (1988), they are:

1. discriminations -- the ability to distinguish one feature of an object from another, which includes distinguish-

ing one symbol from another. . . .

2. concrete concepts -- classes of object features, objects and events. . . .

3. defined concepts -- concepts of objects, object qualities, and relations [that] cannot be identified by pointing them out. They must instead be defined. . . .

4. rules -- rules make it possible to do something, using symbols (most commonly, the symbols of language and mathematics). . . .

5. higher-order rules -- a rule . . . [that] differs only in complexity from the simpler rules that compose it. . . . (p.47, 49, 50, 52)

Learning task analysis. The third component of task analysis, learning task analysis, reveals the "internal conditions" necessary for learner attainment of the stated outcome objective. More specifically, this analysis consists of determining: (a) the prerequisites of learning, and (b) the sequencing of content to attain the chosen outcome. This information is revealed on the basis of the category of learning outcome to which the objective is assigned. In other words, for each category of learning outcome, task analysis prescribes important instructional conditions.

Prerequisites

Gagné (1985) remarked that learning task analysis "seeks to identify the prerequisites for the learning of the total task and any of its subtasks that are not already well established" (p.280). As Briggs and Wager (1981) suggested, "prerequisites are considered to be 'enabling objectives;' that is, objectives that must be learned to enable the learning of other objectives. Enabling objectives define the requirements for learning the terminal objective" (p.105).

Prerequisites of learning are of two kinds: essential, or enabling prerequisites, which are subordinate skills that enable the learner to achieve the terminal objective; and supportive prerequisites, which are useful to facilitate learning, but not essential for learning to occur. Either of those types of prerequisites may be appropriate for any given outcome (Aronson & Briggs, 1983; Gagné, 1977, 1985).

Sample Design Procedure

In order to provide an example of the procedure for the design of instruction using task analysis theory, the highest ranked outcome objective from the aforementioned preliminary list was selected. That outcome states that "the student will be able to state the need/value of being 'technologically literate'." Because this outcome falls within the "verbal information" category, particular types of essential and supportive prerequisites (i.e., enabling objectives) were prescribed by task analysis theory.

Learning of "verbal information" is facilitated through two major essential prerequisites: (a) concept meanings, and (b) sentence syntax. In other words, as Gagné and Driscoll (1988) indicated:

> **verbal information**, when it is to be encoded and stored as organized knowledge, requires that the learner know (as enabling prerequisites) the meaning of the words or phrases that make up the information. That is, these words or

phrases must be known as **concepts** (an intellectual skill). More than this, the learner must be able to understand sentences, which involve syntactic **rules** (for example, subject-verb-object). (p.114)

Basic rules of language (i.e., syntactic rules) are for the most part acquired at an early age. As Gagné (1977) confirmed, "the essential prerequisites for acquiring verbal information make up a set of intellectual skills that are usually learned early in life, and are therefore well- practiced skills of language usage" (p.136-137). As such, the focus in this paper regarding essential prerequisites for learning relative to the outcome chosen consisted only of learner acquisition of necessary concepts and phrases.

Analysis of the learner outcome objective "the student will be able to state the need/value of being 'technologically literate'" reveals the essential prerequisites of learner acquisition as the concepts "technology," "literacy," and "technologically literate," as well as the phrases "the need of being technologically literate" and "the value of being technologically literate." Those outcome objectives are outlined in Table 2. In the event that the students did not have an understanding of the concepts "need" and "value," those concepts would have to be taught in addition to the enabling objectives (Gagné, 1977).

In accordance with task analysis theory, the essential prerequisite objectives of classifying the concepts "technology," "literacy," and "technologically literate" were categorized within the "intellectual skills" category of learning outcomes. In particular, these concepts fell within the "defined concepts"

Table 2
Sample Terminal and Enabling Outcome Objectives

Terminal (Unit) Outcome Objective:

The student will be able to state the need/value of being technologically literate.

Requisite Terminal (Unit) Outcome Objectives:

1. The student will be able to state the need(s) to be technologically literate.

2. The student will be able to state the value(s) of being technologically literate.

Enabling Outcome Objectives:

THE STUDENT WILL BE ABLE TO:

1. Classify by definition the concept "technology"
2. Classify by definition the concept "literacy"
3. Classify by definition the concept "technologically literate"
4. State the meaning of the phrase "need to be technologically literate"
5. State the meaning of the phrase "value of being technologically literate"

sub-category. In task analysis, the categorization of prerequisites into a different category of learning outcome than the terminal objective is relatively common. Specifically, as Gagné (1985) remarked, "notable . . . is the frequency with which intellectual skills appear as prerequisites of other kinds of learning outcomes, such as the learning of information . . . " (p.271).

The major supportive prerequisites for learning "verbal information" are "schemas of organized knowledge that are familiar and relevant to the new information being learned" (Gagné & Driscoll, 1988, p.114). Stated differently, as Gagné (1977) remarked, "evidence from a variety of sources indicates that single items of information are most readily learned and retained when they occur in a larger context of meaningful information" (p.137).

Guidelines regarding sequencing of content are also prescribed through learning task analysis. In the case of "verbal information," sequence of presentation is not important--the new information must simply be presented in such a way that the learner is able to relate it to previously learned information (Aronson & Briggs, 1983; Petry et al., 1987).

Sequencing of "intellectual skills," such as the prerequisite tasks of the sample terminal outcome objective, requires development of a learning hierarchy. According to Aronson and Briggs (1983), a learning hierarchy is a diagram that shows "essential prerequisites and their relationship to one another . . . The terminal skill is at the top and below it are the essential prerequisites" (p.86). Thus, sequencing is prescribed by breaking each terminal objective down into "enabling objectives, each of which may have several subordinate objectives" (Gagné & Briggs, 1979, p.137).

As Petry et al. (1987) proposed, a sequence is then developed in which the component skills are taught in a parts-to-whole sequence; first the most elemental parts at the bottom of the hierarchy are taught, followed by progressively more complex combinations of the parts. (p.22)

The chosen terminal outcome objective for the sample design procedure is composed of two requisite terminal outcomes that comprise it, and the enabling objectives are those that must be attained prior to the requisite terminal outcome objectives. Sequencing of the enabling objectives is prescribed from simplest to more complex. In other words, a student must first be able to classify the concepts "technology" and "literacy" before being able to classify the concept "technologically literate," and so on. This instructional sequence, represented in a learning hierarchy, is presented in Figure 1.

Summary

In an effort to facilitate the integration of environmental education in general, and into technology programs in particular, the issues of where such content should be taught, what should be taught, and how it should be taught were presented. It is hoped that the information contained herein will provide a starting point for the systematic design of instruction to integrate environmental education content curricula-wide.

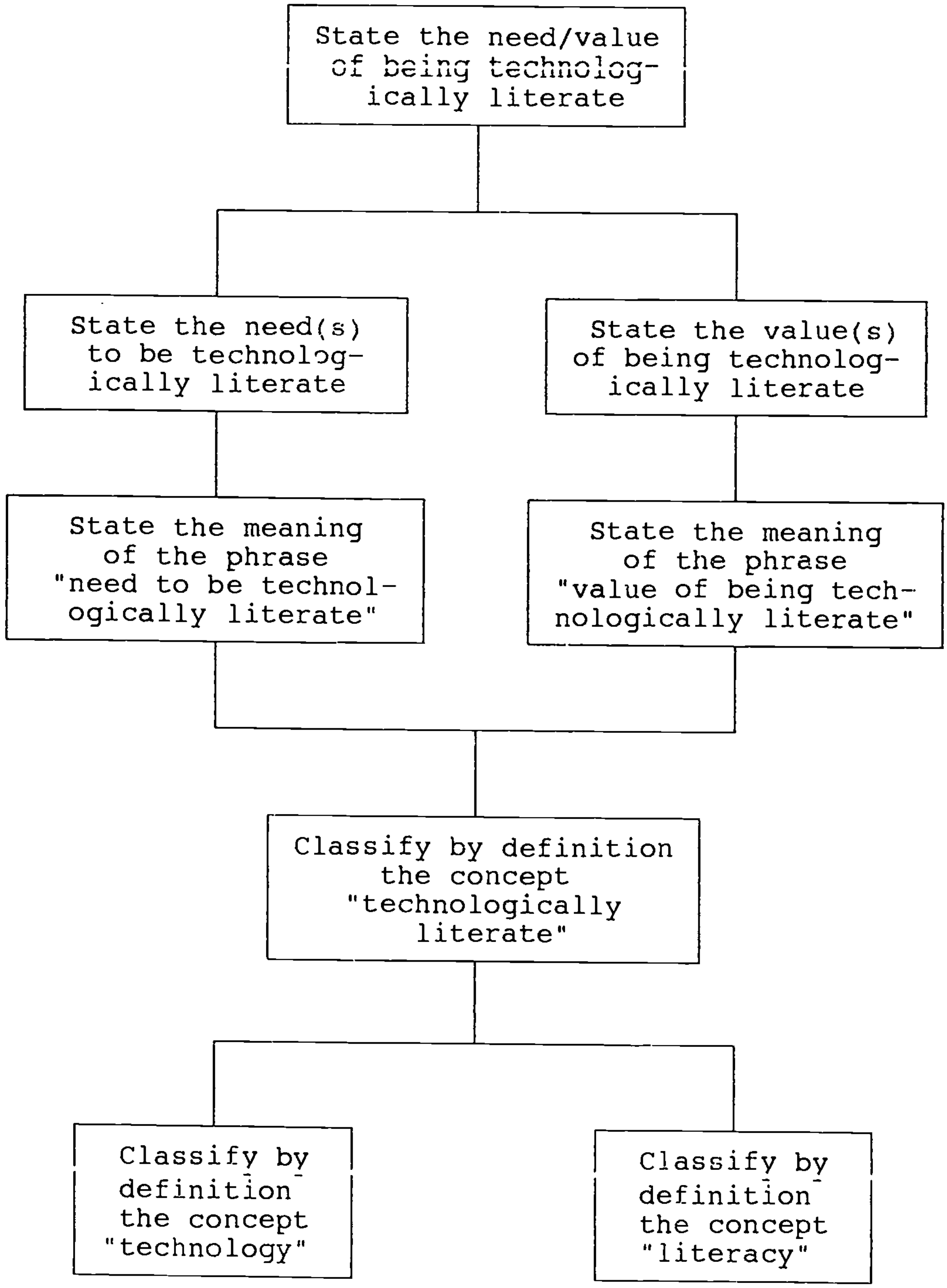

Figure 1. Sample Learning Hierarchy

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