

Technology and Efficiency: Competencies as Content

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Curriculum proposals and counter proposals characterize technology education. Some proposals enjoy widespread attention, others attract only momentary notice. Considerable incongruity, moreover, sometimes exists between stated objectives and the methods proposed to achieve them (Clark, 1989). One source of uncertainty is the lack of clearly articulated curriculum designs. A curriculum design pattern provides a logical way to organize instruction. However, as Eagan (1978) observes, uncertainty over how the curriculum should be organized leads to uncertainty about content.

Industrial arts historically has drawn heavily from the competency, or what is more recently termed the technical/utilitarian design pattern (Herschbach, 1989; Zuga, 1989). The technical/utilitarian pattern undergirds much of what is being termed technology education, although a considerable lack of clarity may accompany its application. The purpose of this paper is to examine the use of the technical/utilitarian design pattern and its application to technology education. However, competencies, the older, but shorter term will be used throughout this article.

Comparison With Other Design Traditions

Curriculum theorists generally agree that there are variations of five basic curriculum design patterns, used singly or in combination: a) academic rationalism; b) competencies (technical/utilitarian); c) intellectual processes; d) social reconstruction; and e) personal relevance (Eisner, 1979; Eisner and Vallance, 1974; Orlansky and Smith, 1978; Saylor, et al., 1981; Schubert, 1986; Smith, Stanley and Shores, 1959). There are important differences between each design pattern.

In general, the *competency* pattern is characterized by the application of what is commonly termed an “ends-means model,” popularized by Robert Tyler in the 1950s. Objectives, the ends of instruction, are first identified. The content of instruction is selected to address the objectives, and the various instructional elements, the means, are then designed to assist students in attaining the objectives. This is a characteristic also shared with the *academic rationalist* design pattern.

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In contrast, the *social reconstruction* and the *personal relevance* patterns place less emphasis on predetermined content. The term “curriculum development” is used in the broad sense, referring to both identifying the content and developing the accompanying instructional materials, student activities, evaluation items, and so on. This is because the selection of content is thought to be influenced in part by what is known about the learner and individual differences in background, ability, interest, and learning style. There is less concern for learning particular knowledge, so little distinction is made between the what (content) and how (delivery system) of instruction. What students are expected to learn is a product of the instructional activities, and may vary between learners. This is because it is thought that instructional content cannot be fully specified until student characteristics and interests are taken into account (Egan, 1978).

The *process* pattern can fit into either of these general groups, depending on the particular objectives of instruction. This is because there is no set way of organizing content. Thus, the process design can be integrated into an academic rationalists or competency pattern, or it can complement the social reconstruction and personal relevance designs.

Technical instruction when organized within the framework of a competency design has other distinguishing characteristics. One of the most notable features is that it is *performance*, rather than subject oriented. This is the difference between technical instruction and instruction in formal subjects, such as biology, physics or economics. This is a difference that sets the competency pattern off from the academic rationalist design. Although formal subject matter from the disciplines is used, the technical activity is the basis for determining what formal subject matter to select. The subject matter selected for instruction relates directly to the technical activity. The link between instruction and the use of skills is direct, and functional.

Efficiency is a concept fundamental to the design of instruction based on the competency pattern: Instruction is efficient to the degree that course objectives are mastered. Instructional efficiency is achieved through the teaching methods, activities and instructional materials designed to guide learning. This is commonly referred to as the instructional “delivery system.” Of course, the delivery system is designed to accommodate student background, learning differences between students, and available resources. When instruction is rationally designed, incorporating sound principles of learning, greater instructional efficiency results.

Instruction based on the competency pattern tends to be characterized by lists of objectives; ordered instructional sequences which relate to the objectives; highly organized instructional systems; and measures of performance which assess the outcomes specified in the objectives. The content of instruction is identified through one of many analytical procedures used to identify technical skills, including manipulative, process or conceptual. The relationship between all of the instructional components is direct and functional (Molnar and Zahorik, 1977).

Historical Overview

The systematic design of technical instruction based on competencies has a rich tradition. Charles Allen's influential work *The Instructor, the Man and the Job*, published in 1919, demonstrated the usefulness of organizing instruction into logical units which could be standardized among different training locations. The effectiveness of instruction was no longer based solely on the ability of the individual instructor, but was also due to the quality of the design itself, which served to guide the instructor and provided the basis for planning, conducting and evaluating instruction. Subsequent work by W. W. Charters (1923), Robert Selvidge (1923; 1926), Selvidge and Fryklund (1930) and others helped to develop a framework for the systematic analysis of instructional content and the design of instructional materials.

These early efforts were applied during World War II to the training of military personnel and production workers. The effectiveness of deliberately planned and systematically organized training was clearly demonstrated. Following the war, government groups and private industry, convinced that quality and productivity could be improved through systematic training, invested in research and development. This work established the foundation for contemporary instructional design practice. Theoretical constructs were formulated along with practical procedures which helped to guide instructional development and implementation. There was a direct impact on public education as new ideas found a place within the educational literature. The military and industry, for example, originally funded much of the work carried out by influential researchers such as Miller (1962), Mager (1962), Gagne (1965) and Butler (1972). The results of their work were applied to the design of public instruction.

The scope of activity also expanded significantly. At least five lines of research which impacted on instructional design were pursued:

1. attention was focused on the need to clearly specify objectives in observable and measurable terms;
2. measurement and evaluation concepts were advanced, making it possible not only to directly measure learning outcomes but also to assess the efficiency of the various instructional components;
3. learning theory was merged with instructional design theory;
4. advances were made in the use of instructional materials and educational technology; and
5. instructional system models were formulated.

By the 1970s sufficient theory and practice existed to build well- conceived, efficient, integrated systems of instruction. Instructional development evolved into a large enterprise serving government and military groups, private industry, public education and related professions.

The 1980s have seen additional instructional system refinement, particularly in the application of learning theory and the use of educational technol-

ogy. Computer technology especially is a current focus. Present models for the design of technical instruction build from a rich body of knowledge, and draw concepts and practices from a diverse stream of influence, including industrial psychology, skills analysis, programmed learning, measurement and evaluation, media design and learning theory. There also has been a convergence of practice. In theory and substance the instructional design models used in vocational and technical instruction differ little from those applied to industrial training and to other subject fields which emphasize improving practice. Essentially, a rational, problem-solving approach is applied to the design of instruction.

Industrial arts educators have made extensive use of the competency design pattern (Herschbach, 1989; Zuga, 1989). However, its application has been less specific and tied less directly to training for specific jobs. The instructional models are less elaborate than those applied to industrial or military training, yet the same basic conceptual framework is used; and although the underlying efficiency rationale often may be masked by broad educational and social objectives, the attainment of specific learning outcomes is the intended final instructional result. Differences are in the specificity of instruction, rather than in the overall design pattern. Industrial arts educators have been less concerned with the development of high levels of technical skills and with in-depth skill development in selected technical areas.

Knowingly or not, technology educators also use the competency pattern, particularly in those programs which center on technical specialties (Zuga, 1989). As an outgrowth of industrial arts, some of the same industrial design practices are followed in technology education. The unit shop continues to be widely used (Smith, 1989; Virginia Polytechnic Institute and State University, 1982). The tendency, however, is to align program design more closely with the work of Tyler rather than with the elaborate models currently used in industrial or military training.

Tyler: Formulating a Model

There have been many characterizations of the instructional design process. The most fundamental and influential has been the work of Ralph W. Tyler, set forth in *Basic Principles of Curriculum and Instruction* (1949). To understand Tyler's work is to understand the basic concepts behind the design of technical instruction structured around competencies.

Tyler advanced a fundamental, but simple, idea that profoundly influenced the course of instructional design; namely, that decisions about the ends of instruction, the objectives, should be made first and that all other decisions should follow. He reasoned that it was first necessary to have clearly in mind what is to be taught before actually proceeding with designing instruction. "Objectives," said Tyler, "become the criteria by which materials are selected, content is outlined, instructional procedures are developed and tests and examinations are prepared" (1949, p. 3). Although this may now seem like a common sense idea, it has served as the foundation for considerable subsequent instructional design work. With the publication in 1962 of Mager's book *Preparing Instructional Objectives*, the idea of first formulating objectives became popularized.

As previously discussed, instructional systems characterized by the use of objectives are based on what is commonly termed an "ends-means model" of instructional design. As the name suggests, decisions about the objectives--the ends of instruction--are separate from, and made prior to, decisions about the means--the instructional activities, materials and so on designed to facilitate learning. The various instructional elements are designed to assist students in attaining the objectives.

The ends-means model provides a way to directly relate instruction with outcomes. All of the instructional components used are developed from, and support, the attainment of the objectives. Tyler (1949) realized the complexity of the learning act, but he reasoned that if the related instructional components were focused on the attainment of the wanted behavior, there was a high probability that the desired outcomes would be realized. *Efficient* instruction would result.

While Tyler's early work has been reformulated, extended and improved since the publication of this influential volume in 1949, the basic instructional design tasks remain the same. The instructions designer must identify:

1. What is the purpose of instruction?
2. What educational experiences should be provided in order to attain the purpose?
3. How can instruction be effectively organized?
4. How can instruction be best evaluated?

While retaining the basic rationale and substance of the Tyler model, Taba (1962) developed seven explicit steps:

1. Diagnosing of needs
2. Formulation of objectives
3. Selection of content
4. Organizing of content
5. Selection of learning experiences
6. Organization of learning experiences
7. Determination of what and how to evaluate

Selvidge: Influencing the Field

One effort to develop a program of study for industrial arts based on competencies centers around the work of R.W. Selvidge at the University of Missouri. Selvidge's model fits within the Tyler framework, and it has continued to influence instructional design.

Although he was mainly concerned with trade and industrial training rather than industrial arts education, the analysis approach advocated by Selvidge was sanctioned in the 1930s by the American Vocational Association as being appropriate for industrial arts. The aim was to bring elements of manual training, manual arts and vocational education together. Many industrial arts educators adopted the analysis approach to the selection of content material. Several variations of this approach were widely used, and job and trade analysis are still the dominant method of selecting course content material for technical instruction (Herschbach, 1984).

Analysis, as developed by Selvidge, was an adaptation and alteration of elements from both manual training and manual arts. It incorporated the shop project as an essential aspect of instruction, as well as industrial processes, material and related information. Content was selected by an analysis of a trade or occupation for materials that would achieve the instructional objectives of the course. Instruction was broken down into units entailing operations and jobs. The content selected tended to be heavy on the manipulative side, and this was viewed as being appropriate for pre-vocational or vocational development.

While there is variation among advocates, the basic method and sequence are as follows:

The first step is to determine the objectives of the program of studies; these comprise "the information skills, attitudes, interests, habits of work we expect the boy to have when he has completed his period of training" (Selvidge and Fryklund, 1930, p. 36).

Secondly, an analysis of the subject field should be made in order to arrive at the main divisions of the field. For instance, "a course for automotive mechanics might logically be organized into such divisions as

engine, power transmissions, chassis, electrical and body repair; these main divisions are then further analyzed” (Giachino and Gallington, 1954, p. 68).

The next step is the selection from the analysis of those items that are appropriate for the length of the course, student ability, course level, available equipment, and the general objectives. The total course content material comprises a list of: “things you should be able to do” (operative skills), “things you should know” (information necessary for successful performance of the skills), and “what you should be” (attitudes and habits necessary for successful performance).

Lastly, the course content material should be formulated into a course of study, with teaching materials organized and arranged for instructional use. Instructional sheets are often used for this purpose. Practice work, production and individual projects are used.

Selvidge developed a procedure through which technical instruction could be systematically designed by the classroom teacher. Much as Charles Allen (1919) had done before him, Selvidge provided a way by which instruction could be standardized and instructional quality resulted from the design process itself. Efficiency was to be the outcome. Selvidge's wide success, however, provoked opposition. Some considered that instruction was too vocational to be appropriate for industrial arts. Particularly vocal was William E. Warner (Evans, 1988).

Warner: Reflecting Industrial Categories

Warner's deep opposition to Selvidge was no doubted rooted in his own instructional plan. Warner largely discounted the analytical method as developed by Selvidge for identifying instructional content. Instead, instruction would take place within the “Laboratory of Industries” through selected industrial categories, such as metalworking, ceramics, and communication. Exploratory, vocational, consumer, artistic and developmental objectives would be stressed (Warner, 1936). Developments along Warner's ideas took the form of segments, or categories, of industry, such as graphic arts, metals, and woods, as representative areas of instruction. Later, largely through the work of his graduate students, the general categories of power, transportation, communication, construction and manufacturing were stressed (Warner, 1948). The Industrial Arts Curriculum Project (IACP) included only two, construction and manufacturing (Journal of Industrial Arts, 1969). More recently, the Jackson's Mills group has suggested communication, construction, manufacturing and transportation (Hales and Snyder, 1982).

However, Warner was unable to develop a practical way to derive specific instructional content from the larger instructional categories. He was never explicit about the relationship between objectives and course content. In other words, how did objectives translate directly into what students were to learn? As Taba (1962) observes, this is always difficult to do because focus is lacking. The categories are general organizers, “but set no guideposts to what should be emphasized, and what not” (p. 304). Consequently, in much of Warner's

work there was inconsistency between the curriculum rationale and the content selected (Bruner et al., 1941). Moreover, it was not uncommon for practitioners to apply Taylor's concepts to the selection of instructional content while still retaining the more global organizers characterizing Warner's work. This practice continues today.

Gordon Wilber: Finding the Middle Ground

Gordon Wilber's (1948) work is significant in that he occupied the middle ground between two extremes: Selvidge and Warner. Basically using Tyler's approach to the design of instruction, Wilber proposed that content selection start from a set of general objectives, followed by specific behavioral objectives. Lessons, projects and activities would next be developed to effect the desired behavioral changes. Subject matter was considered as being two types: manipulative, involving the use of tools and materials, and resulting in projects; and related material.

Although Wilber's program is an amalgamation of the two approaches by Selvidge and Warner, it was couched in sounder pedagogical terms. Like Tyler, Wilber's model included a clear progression from goals to content and learning activities, culminating in evaluation. By following the ends-means model proposed by Tyler, there was a logical way to bridge the gap between the general curriculum organizers proposed by Warner and others and specific instructional content. At the same time, by focusing on general objectives, Wilber avoided the close resemblance to vocational instruction which so often characterized the programs patterned after Selvidge.

Attesting to Wilber's influence, a curriculum development model based on behavioral changes was adopted by the American Vocational Association in 1953. Throughout the 1970s the American Industrial Arts Association supplied guidelines for incorporating behavioral outcomes into instructional programs. Through the work of Mager (1962), Popham and Baker (1970) and others, "competency-based" instruction became popularized. Few areas of study in public education were immune to its influence in the 1970s, and the Tyler model exerts a pervasive influence today. "The power and impact of the Tyler model cannot be overstated," Molnar and Zahorik (1977) observe. "Virtually every person who has ever been in a teacher education program has been introduced to this model. It has been synonymous with curriculum work at all levels" (p. 3).

Subject areas, such as science instruction, mathematics, and English tend to draw course content from the disciplines, rather than work activity, and they are based on the academic rationalist design pattern. This sets them off from technical subjects such as technology education and vocational instruction. Nevertheless, the "delivery system" (the objectives, course material, activities, and evaluation items) reflects the ends-means model. Moreover, efficiency is the underlying objective of both (Herschbach, 1989). When educators talk about basic skills testing, greater accountability, or a more rigorous curriculum,

they are talking about greater efficiency. In general, American education for at least the past three decades can be characterized by an efficiency thrust.

The Challenge

All forms of public technical education use the competency design pattern. Its application, however, is less sophisticated than is found in military and industrial applications. It is more akin to the work of Tyler and Wilber than to the elaborate design models currently in use. It is applied in a more abbreviated form. As technology educators ponder the curriculum challenges of the future, to what extent can the competency pattern serve to guide curriculum development?

The efficiency rationale is, and will continue to be a major goal of American education. Financial constraints, the alarm over low student achievement levels, the competition of a global economy, political ideology, these and other factors which shape the public's perception of education, will continue to drive the objective of efficiency. At least since Selvidge's day, industrial arts educators (and presently technology education supporters) have adhered to the efficiency rationale, even if unknowingly. The concept of technological rationality is inherent in technical instruction (Molnar and Zahorik, 1977). Perhaps for this reason, the competency design will continue to have wide appeal.

However, if the competencies design is to serve as a major organizing pattern for technology education it is essential to address at least three major issues.

First, theorist must clarify the *educational* function of technology education so that there is a direct relationship between the ends and means of instruction. Conceptual inconsistency has been a characteristic mark of the movement (Herschbach, 1989; Clark, 1989; Zuga, 1989). However, as Egan (1978) notes, "If one lacks a clear sense of the purpose of education then one is deprived of an essential means of specifying what the curriculum should contain" (p. 69).

Whether or not the efficiency rationale should be the major underlying rationale of technology education, and whether the competency design should be a major organizing framework is open to debate. Other objectives, which are largely the outcome of other design patterns, certainly merit consideration.

Second, the relationship of technology education to the separate subjects design pattern must be clarified. As previously discussed, the competencies and academic rationalists design patterns both share the common rationale of efficiency, and both make use of Tyler's ends-means model. The two patterns are used in combination, but depending on how they are used results in distinctly different curricula.

The supposition that technology is a discipline (separate subject), reducible to discrete units of instruction similar to that found in the teaching of mathematics, English or physics, is open to question. As Frey (1989) suggests, "technology is grounded in 'praxis,' rather than abstract concepts, or 'theoria'

(p. 25). And while technology can be characterized as object, process, knowledge, and volition, these characteristics manifest themselves through human activity (Frey, 1989). However, to the extent that technology is conceived as an intellectual discipline to be studied rather than activity to be engaged in, there is less room for the application of the competency design pattern.

Third, and perhaps most important, the content of technology education must be conceived in broader terms than is usually achieved by the application of the competency design to curriculum development. Use of the competency design pattern often results in narrowly prescribed instructional content, such as that found in the work of Selvidge. Application of the Tyler model to curriculum development can result in a static instructional design (Smith, Stanley and Shores, 1957; Molnar and Zahorik, 1977). These limitations, however, can be overcome. To do so means defining competencies in broad terms. Competencies are more than the ability to manipulate tools, use material and apply mechanical processes. Problem solving, critical thinking skills, ordered ways of working — these are competencies that can also be identified. The analytical methods formerly applied to identify job tasks and tool operations can be equally applied to the identification of broader conceptual learning and general educational outcomes. Gordon Wilber demonstrated this. Particularly appealing is the idea of effecting a synthesis with the process design pattern.

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