A MODEL CURRICULUM FOR HIGH SCHOOL METALLURGY

DISSERTATION

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF EDUCATION

By

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The problem of this study is the development of a model curriculum for high school metallurgy students. The study was made at the Skyline Career Development Center of the Dallas Independent School District, Dallas, Texas.

The study has three purposes. In addition to providing a model curriculum for high school metallurgy students, a second purpose is to describe the developmental processes by which the curriculum was derived. The third purpose is the evaluation of the basis of the content of the model curriculum.

The curriculum developed is described in three sections, one for each of the volumes produced: Student Learning Plan, Evaluation Instruments, and Teacher Implementation Plan. The contents of each volume are described as well as procedures for using the curriculum materials.

The description of the developmental processes used in the production of the model curriculum deals with such aspects as beginning the development of a career curriculum, coordinating the efforts of personnel, and identifying and validating the content for the curriculum.

The skills and concept-relationships upon which the curriculum was based were validated by a twenty-member

Committee of Authorities. Inquiry was made, by use of a rating instrument, of each member of the committee as to usefulness of the skills in current metal industry and/or to the appropriateness and universal truth of the concept-relationships on which the skills were based.

The data on the rating instruments were tabulated and compared with established criteria to determine whether to change or delete any parts or to retain the material as originally written. The completed curriculum under the title Materials Processing and Quality Control was implemented by the metallurgy instructor at the Skyline Career Development Center. The student materials and the criterion-referrenced evaluation instruments were found to be effective in helping high school students to accomplish career competency goals.

It was found that of the 76 concept-relationships stated, 64 were true as originally written according to the established rating criteria. It was also found that 64 of the 76 concept-relationships stated were appropriate for understanding by high school students, although the two lists of 64 concepts were not identical. The unapproved concept statements were deleted or rewritten according to the established criteria. Only one of the 33 skills listed received a low rating.

It was further found from a report of the metallurgy instructor that the 21 high school students in the metallurgy program had attempted a cumulative total of 374 of the 33 behavioral objectives in the curriculum and had accomplished a total of 289, or 78 per cent. Only 85 objectives, or 22 per cent, attempted were not completed, and 26 of these 85 were not finished because of a lack of time at the end of the school year.

The conclusions that seem to be supported by the findings of the study provide evidence that a skills curriculum can be based upon concept-relationships and that the model curriculum developed can be accomplished by high school metallurgy students. Further, it appears that the use of the cooperative efforts of personnel representing both industry and the schools is a valuable procedure in the production of curriculum programs for career education.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Career education has as its major concern the preparation of citizens for meaningful, productive, satisfying careers. To accomplish this task, consideration of several aspects of the existing technological society is most important. There is a knowledge explosion. Thousands of technological discoveries and advances are made annually. Specific job titles rapidly become obsolete.

Curricula for career education must, therefore, provide the student with basic concepts and understandings in his chosen field of endeavor. One does not "teach" concepts. Concepts are developed through planned activities which direct the learner toward making generalizations. Concepts are acquired at the same time skills and abilities are learned. Having developed such concepts makes it possible for the student to transfer his knowledge to the performance of other skills in related fields of endeavor.

Statement of the Problem

The problem of this study was the development of a model curriculum for high school metallurgy students.

Purposes of the Study

The purposes of this study were:

1. To describe the developmental processes by which the model curriculum was derived.
2. To provide a model curriculum for high school metallurgy students.
3. To evaluate the basis of the content of the model curriculum.

In order to fulfill the purposes of the study, answers to the following questions were sought.

In relation to stated purpose one, the following questions were formulated:

1. How should the development of a career curriculum in a local school district be started?
2. How should efforts of school personnel be coordinated in the development of the program?
3. How should the content for the curriculum be identified and validated?

In relation to stated purpose two, the following questions were formulated:

1. What characteristics should the student's model curriculum materials have?
2. What characteristics should the student's evaluation instruments for the model curriculum have?

3. What characteristics should the instructor's model curriculum materials have?

In relation to stated purpose three, the following questions were formulated:

1. Is the content of the model curriculum based on true concept-relationships?
2. Are the skills taught in the model curriculum those which are currently used in industry?
3. Can this curriculum be accomplished by high school metallurgy students?

Background and Significance

A decided need for additional research in the field of curriculum development was indicated by Passow when he stated, "Research is needed for developing and testing conceptual frameworks and theories that underlie curriculum building. . . ."[1] This research study was descriptive in nature in that it was intended to describe a specific set of phenomena as they pertain to a model program for teaching metallurgy. The study had an aspect of evaluation of the kind described by Fox in that an evaluative judgment had to be made about the research situation. Fox concluded that such research "can be conducted with only one group and need

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[1]A. Harry Passow, "Curriculum Research: Status, Needs, and Prospects," Educational Research Bulletin, XXXIX(November, 1960), 197-205.

not have any group to group comparison at all."[2] The problem with such research was with the establishment of validity. In order to establish the effectiveness of such a program, the criteria had to be stated before the survey evaluation. In addition to setting the standards in advance, the researcher had to decide in advance how many respondents would be required to meet the criteria.[3]

With the preceding considerations in mind along with attention to the knowledge explosion, individual differences, and individual interests,[4] special attention was given for this model to the direction of current curriculum change, use of concepts and concept teaching, and procedures for evaluation of models. Differences from other models were established.

One of the present trends in the field of industrial arts curriculum development is an attempt to provide students with a broader understanding of the functioning of industry. More current practices are to be found in school

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[2]David J. Fox, The Research Process in Education(New York, 1969), p. 434.

[3]Ibid., pp. 434-436.

[4]Leonard C. Silvern, Systems Analysis and Synthesis Applied Quantitatively to Create an Instructional System (Los Angeles, 1960), pp. 77, 79.

laboratories while at the same time fewer specializations in particular skills are emphasized.[5]

A second trend in curriculum development in general is to give more consideration to local needs and requirements. One way of doing this is the formation of advisory committees.[6] Members of such a committee from outside the local school district may include such persons as consultants from colleges and universities, subject-matter specialists, professional organization members, laymen who are authorities in their fields, and laymen who author books and articles in the subject-matter area.[7] Scriven stated that often such a group is better equipped to evaluate programs than are professional evaluators.[8]

Another trend is that of generalizing the curriculum. This is pointed out by Swanson who emphasized that:

> Perhaps the most important feature of any occupational experience program is its modus operandi. The problem is not merely one of achieving desired learning outcomes, but one of teaching for them in such a way

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[5]Ronald C. Doll, Curriculum Improvement: Decision-Making and Process(Boston, 1970), p. 122.

[6]Lloyd J. Phipps, "Curriculum Development," Review of Educational Research, XXXVIII(October, 1968), 367-368.

[7]Doll, op. cit., p. 267.

[8]Ralph W. Tyler, Robert M. Gagne, and Michael Scriven, Perspectives of Curriculum Evaluation(Chicago, 1967), p. 57.

that the behaviors will be generalizable, transferable, and durable.[9]

Finally, Phipps identified from a review of recent literature, five additional trends in curriculum development:

1. Identification of content common to clusters of occupations
2. Development of curriculum for students with special needs
3. Adaptation of curriculum to changes in educational approaches and technology
4. Identification of curriculum changes required by technological developments
5. Attention to occupational areas that were previously overlooked or considered unworthy[10]

It was believed that each of these items was in some measure defensible as related to the field of metallurgy.

The definitions used in specific relation to this study were designated following consideration of varied definitions. The term <u>concept</u> means different things to different people.[11] Concepts may be considered ideas or abstractions. They may be determined by their intrinsic attributes or in terms of behaviors or operations which they represent.[12] Anderson believes a person has acquired a concept, "if he can identify instances of the concept and discriminate them from

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[9]Gordon I. Swanson and others, "A Conceptual Framework," <u>American Vocational Journal</u>, XLIV(March, 1969), 24.

[10]Phipps, <u>op</u>. <u>cit</u>., p. 377.

[11]Herbert J. Klausmeier, <u>Concept Learning: A Bibliography 1950-1967</u>(Madison, Wisconsin, 1969), p. 3.

[12]<u>Ibid</u>., pp. 3-4.

non-instances."[13] The concepts to which he referred are of the one-word type, but the same should be true of concept-relationships.

The nature of concepts was also dealt with by Archer from the standpoint of identifying attributes. His definition is, "the label of a set of things that have something in common."[14] He too was dealing with one-word concepts. He identified the psychological characteristics of concepts as being identifiability, learnability, labelability, transferability, and forgetability.[15]

Three authors pointed out the importance of the use of activities in the development or learning of concepts. Anderson stated that concepts are theoretical and not concrete--something that results from a variety of experiences and not a single experience. Not only are experiences necessary to arrive at the concepts, but students need opportunities to apply the concepts to meaningful, relevant situations to determine their adequacy.[16] Novak emphasized

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[13] Richard C. Anderson and Raymond W. Kulhavy, "Learning Concepts from Definitions," American Educational Research Journal, IX(Summer, 1972), 385.

[14] James E. Archer, "The Psychological Nature of Concepts," Analyses of Concept Learning, edited by Herbert J. Klausmeier(New York, 1966), p. 37.

[15] Ibid., pp. 40-45.

[16] Herbert A. Anderson, editor, "American Industry--A New Direction for Industrial Arts," Man/Society/Technology, XXX(May-June, 1971), 251.

the importance of selecting the appropriate experiences at each grade level that contribute to the understanding of the conceptual scheme.[17] This idea was pretty well summed up for the area of industrial arts in the statement that:

> Activity-oriented industrial arts . . . provides a natural basis for the assimilation and integration of facts, principles, and concepts related to career education. . . .[18]

Often concepts are found in chains in which they are related to each other such as in the example given by Sax: "All matter is composed of units called fundamental particles."[19] Many authors refer to such chains of concepts as principles or generalizations. However, the example given is not a complex generalization in that the concepts involved are related only to terminology thus forming a definition. The concept-relationship statements defined in this study are of a somewhat higher level, showing relationships of the concepts to each other through processes of comparison, change, organization, or cause-effect. A better example of this type of statement is given in an Indiana State

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[17]Joseph D. Novak, "The Role of Concepts in Science Teaching," Analyses of Concept Learning, edited by Herbert J. Klausmeier(New York, 1966), p. 246.

[18]James E. Good and Mary G. Good, "Industrial Arts Involvment in Career Education," Man/Society/Technology, XXXI(April, 1972), 206.

[19]Gilbert Sax, "Concept Formation," Encyclopedia of Educational Research(Toronto, 1969), p. 201.

curriculum guide for citizenship: "All of man's social institutions are influenced by geography."[20]

Although the terminology is often varied, the importance of the use of concepts and concept-relationships in teaching procedures is pointed out in several pieces of literature. An important point is that statements of concept-relationships are not presented to the student for consideration and especially not for memorization. If the learning is to be lasting, the concept or generalization must be formed by the student:

> . . .the instructor directs the presentation of events and outcomes for the learner, but requires the learner to discover the generalization himself.[21]

Russell confirms that in concept formation, ". . .the teacher must encourage children to look for relationships or at least focus attention on certain features of the situation."[22] Later, in his article, Russell stated:

> Many types of curriculum organization may be considered as plans for developing broader and deeper concepts--the cyclic approach to subject matter, the correlation method, and the unit of work represent stages in curricular patterns designed to

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[20]Indiana State Department of Public Instruction, Citizenship: A Curriculum Guide--Grade Nine(Indianapolis, Indiana, 1970), p. 12.

[21]Nicholas M. Sanders and others, "Effects of Concept Instance Sequence as a Function of Stage of Learning and Learner Strategy," Journal of Educational Psychology, LXIII(1972), 235.

[22]David H. Russell, "Concepts," Encyclopedia of Educational Research(New York, 1960), p. 235.

> produce clearer concepts and relationships between them.[23]

The important task of the teacher then is to direct the learner's thinking toward discovery of the concept-relationships. As pointed out by Taylor, this is a far cry from just lecturing. With lecturing, students learn not to think for themselves because the lectures do all of the mental processes that students should be doing: interpreting, summarizing, describing, defining, and discovering relationships.[24]

Once the teacher has directed the student toward discovery of the concept-relationships, it is important that two things be kept in mind. First, more than just a few samples of evidence should be identified by the student to support the concept-relationship. Second, damaging evidence should also be sought.[25] If it is a true concept-relationship, no exceptions or damaging evidence will be found. Supporting evidence and lack of damaging evidence provide a basis for the student to make the learning permanent when he is convinced of its validity.

The teacher's role, then, is a most important aspect of the model curriculum. As Anderson suggests, teacher

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[23] Ibid., p. 329.

[24] Harold Taylor, How to Change Colleges (New York, 1971), p. 85.

[25] Indiana State Department of Public Instruction, op. cit., p. 14.

preparation should be competency-based around such items as experience in industry, understanding of the conceptual approach to teaching, and adaptation to an appropriate teaching format.[26] The teacher should be able to give direction to students which will aid in discovery, transfer, and retention. Kittell emphasized this when he stated:

> In addition to organizing the materials used in learning, teachers should aid pupil discovery by suggesting meaningful relationships on which learners may base discovery and by providing practice with those relationships.[27]

No written program exists which approaches the design of the model curriculum developed in this study. Model programs designed by Silvern deal with individual learning in general,[29] but not with metallurgy, although they do provide some background material for format. Other ideas for format were available in the "Construct of Social Action" as reported by Bertrand in Models for Educational

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[26]Herbert A. Anderson, op. cit., pp. 264-265.

[27]Jack E. Kittell, "An Experimental Study of the Effect of External Direction During Learning on Transfer and Retention of Principles," Journal of Educational Psychology, XLVIII(November, 1957), 403.

[28]Leonard C. Silvern, Systems Analysis and Synthesis Applied Quantitatively to Create an Instructional System (Los Angeles, 1969).

[29]Leonard C. Silvern, Systems Analysis and Synthesis Applied to Occupational Instruction in Secondary Schools (Los Angeles, 1969).

Change.[30] As this name implies, however, Bertrand's report specifically related to school programs or to industrial arts. The closest approach to this model is Developing American Industry Courses for the Secondary Schools, as reported by Gebhart.[31] Several comments concerning the American Industry Project by Anderson have already been used in this study. An additional article concerning the American Industry Project is one entitled "An Approach to Industrial Arts Curriculum Development," by Streich.[32] The likenesses and differences of the American Industry Project to this model are given in the following summary of the information presented in the articles by Gebhart, H. Anderson, and Streich.

Area of Comparison	American Industry	Model Curriculum
1. Subject matter (content)	Industry in general	Metallurgy only
2. Content built on concepts	Yes--uses "principles"	Yes--uses "concept-relationships"
3. Sequence of content	Highly structured	Structured but flexible

[30] Alvin L. Bertrand and Robert C. VonBrock, editors, Models for Educational Change (Austin, Texas, 1968), pp. 63, 71.

[31] Richard H. Gebhart, Developing American Industry Courses for the Secondary School (Menomonie, Wisconsin, 1968), pp. 1-27.

[32] William H. Streich, "An Approach to Industrial Arts Curriculum Development," Man/Society/Technology, XXXI (November, 1970), 62-64.

Area of Comparison	American Industry	Model Curriculum
4. Activities built on concepts	Yes	Yes
5. Length of the program	3 years	2 years
6. Format uses behavioral objectives	Yes	Yes
7. Incorporates learning of specific skills	Yes	Yes
8. Incorporates printed student materials and teacher guide	Yes	Yes
9. Teacher preparation	Requires specified college courses and degree	Requires experience in industry and in-service training in concepts
10. Evaluation procedure	By industrial arts teachers and industrialists	By industrial arts teachers and industrialists

Definition of Terms

The following terms have specific meanings as they were used in this study:

Advisory Committee--a committee selected jointly by the Dallas Independent School District (DISD) and the Dallas Chamber of Commerce to validate the curriculum and assist the cluster in any other ways possible. (Not to be confused with the Committee of Authorities.)

Behavioral Objective--a statement in three-paragraph form giving details of what is expected of the student in working toward the career competency goal.

Career Competency Goal--a brief phrase indicating the goal toward which the student is to work.

Cluster--a number of career courses grouped together to form a coordinated area of learning.

Committee of Authorities--a committee selected according to the methods and procedures section of this study for the purpose of validating the skills and concept-relationships used as the basis for the curriculum. (Not to be confused with the Advisory Committee.)

Concept--a first or second level concept.

First Level Concept--a one-word concept which is a mental image of a thing, an action, or a phenomenon. Examples: metal, receive, heat.

Second Level Concept--two or more words which relate a thing or phenomenon concept to an action concept. Examples: humans learn, light changes.

Concept-relationship--a third level concept in which a thing or phenomenon is related to some other thing or phenomenon by an action or relationship concept. Examples: Organisms produce other organisms. Individuals determine goals.

Evaluation Instrument--a criterion-referenced test requiring written or hands-on responses which demonstrate that the student can accomplish the objective according to the established criteria.

Metallurgy--the study of metals, their characteristics and uses, with development of skill and facility in casting, cutting, forming, shaping, treating, and testing metals.

Module--a chapter in the student curriculum materials containing a behavioral objective and corresponding learning plan.

Limitations

The model designed applied only to high school students, grades 10-12. Content applied only to the field of metal-working and the quality, processing, and testing of metals and metal products.

Basic Assumption

The basic assumption was made that a more effective approach to teaching metallurgy could be found than those which were in practice.

Methods and Procedures

This model curriculum for high school metallurgy students contains three major parts which are described in Chapter II. These parts are the student's curriculum materials, the evaluation instruments, and the instructor's curriculum materials. The three parts are designed to function together as an integrated whole.

The development processes of the model curriculum are also described in Chapter II. This description includes the procedures followed in beginning the project and in identifying the course content as well as the procedures followed in the coordination of personnel during the project. The conclusion of the process was the validation of the content. A vital portion of this study was the process for validation of the skills and concept-relationships for the curriculum. Inquiry was made as to the usefulness of the skills in current metal industry and the appropriateness and universal truth of the concept-relationships on which the skills were based. After classroom use, further inquiry was made as to accomplishment of the skills by the students.

The metallurgy concept-relationships used as the basis for the course content were identified jointly by a metallurgy teacher and a curriculum writer, the author of this study. These were then validated by a twenty-member Committee of Authorities as concepts which are universally true and which are appropriate for a metallurgy course at the high school level. Likewise, the skills to be taught were identified by the teacher and curriculum writer and validated by the Committee of Authorities as skills which are currently in use in the metal industry.

The Committee of Authorities (See Appendix B.) included laymen from industry, university vocational education specialists, public school vocational education specialists, and members of professional vocational organizations for industry and education. Since some of these categories overlapped, the members of the committee were selected in two groups; Group 1, representative of industry, was selected by Bob Sorenson, a member of the American Society for Metals and a superintendent of metallurgical research. Group 2, representative of the field of vocational education, was selected by Pat N. McLeod, a member of the Texas Industrial Vocational Association and the head of vocational-technical education at North Texas State University. Sorenson and McLeod also served as members of the committee.

Reporting forms were provided for the committee members for the purpose of evaluation. (See Appendix D.) These forms were inspected by a preliminary group (See Appendix A.) of three persons in the fields of education and metallurgy to determine if the instruments were clear and understandable. On the forms, each concept-relationship statement was rated as to its appropriateness for a high school metallurgy course and also as to its universal truth (in the opinion of the committee member according to current knowledge). Further, each skill to be taught was rated as to its degree of usefulness in industry or necessity as background material, and thus its value in the course. The instrument for rating the skills used the following five point scale:

5 = Extremely useful
4 = Very useful
3 = Useful
2 = Not very useful
1 = Of no use

An acceptable return of evaluation forms was 75 per cent of the twenty committee members. Information derived from the rating sheets was used as follows:

I. CONCEPT RATING SHEET
   A. Concept was revised if any three members agreed that the statement was not universally true.
   B. Concept was deleted if any three members agreed that it was inappropriate for the course.

II. SKILLS RATING SHEET
   A. Careful consideration was given to revision or replacement of skills rated by three committee members as "1" or "2" on the rating sheet.
   B. Skills were deleted which were rated by three members as "1".

The process for completing the curriculum for the student and instructor involved several aspects. The teacher and writer worked together to provide a sequence of behavioral objectives and evaluation instruments. This material was reviewed by a research and evaluation team under established guidelines. Necessary revisions and corrections were made and activities were written to direct the student toward attainment of the behavioral objectives. These were then edited and proofed and sufficient copies were provided for implementation of the program at Skyline Career Development Center in Dallas, Texas.

During implementation, an evaluation form was given to the instructor to report the accomplishments of the students. From this form, any necessary revisions were made and the curriculum again edited and proofed. After the final curriculum was printed, the curriculum model was considered to be complete.

CHAPTER II

DEVELOPING THE CURRICULUM MODEL

Description of the Developmental Processes

Perhaps the days when a single curriculum writer considered to be an expert in his teaching field sat down and wrote a curriculum alone should be a thing of the past. No matter how much expertise he had in his teaching area, he probably was not trained in curriculum writing, nor did he have the advantage of interacting with other personnel in order to develop materials. This study proposes a different procedure for producing curriculum materials--a procedure involving a number of people, each with a different function--a procedure for the purpose of producing better curriculum materials.

Beginning the Development Process

A school district which provides for career education programs must begin with a commitment to such programs by its board of trustees. It is necessary to provide funds for specialized buildings and equipment to implement such programs. These would probably be provided through a special school bond program.

The Dallas Independent School District Board of Trustees committed itself to provide a curriculum development unit to furnish the career education programs with needed materials. Such materials were not readily available on the market in 1972 because there were few career education programs in existence. Books on various topics were available, but no curriculum programs.

The courses included in the career education programs were selected after gathering input from several sources. Consultants in the school district were asked to submit suggestions for needed courses. The Dallas Chamber of Commerce was asked to participate by making a needs assessment of job market areas. In addition, a survey of students was made to determine areas of interest.

The Dallas Independent School District Curriculum Department for Career Education was created in February, 1971, following a speech by Sidney P. Marland, Jr., U.S. Commissioner of Education, in January of 1971. Development of some career courses began in June of 1971.

Physical facilities were provided for a metallurgy program, but insufficient student requests for the program delayed its beginning for one year. Development of the program began in 1972.

Before that time decisions had to be made as to the specific kind of curriculum to be developed. At least nine months were spent determining desired characteristics, patterns, and formats. By mid-1972 most of these decisions were made. The definition of the curriculum to be developed was:

1. A stable curriculum which identifies and sequences "what is to be taught" (underlying principles or concepts within the subject area that are not likely to change.

2. A flexible curriculum that can be modified as to "how it is to be taught" (new methods, materials, and equipment).[1]

The description of the curriculum to be developed was as follows:

1. Capable of addressing itself to the needs of all learners as a wide range and variety of appropriate activities and ways of assessing behaviors can be developed from the curriculum structure.

2. Constructed to account for teacher differences thus allowing for flexibility in the teaching-learning process by dictating only the understandings to be targeted for, not the teaching method or materials to be used.

3. Capable of interfacing with other subject areas by communicating the conceptual understandings involved rather than specific content appropriate only for that given subject area.

4. Appropriate in structure to be modified in light of any priority goal of the school district by developing activities and evaluating student behaviors compatible with that goal.

5. Capable of being adjusted so the materials can be used at any grade level by developing activities and assessing behaviors at

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[1]"Description of the Curriculum Products," unpublished paper, Dallas Independent School District, Dallas, Texas, 1972, p. 1.

different levels of difficulty to arrive at the same conceptual understandings.

6. Enabling flexibility of measurement to account for differences in learner abilities by using those factors involved in the understandings to assess student behavioral outcomes and not factors restricted to a specific test or situation.

7. Structured to teach thinking and not specific content by assessing the student's ability to apply his understandings to solve new problems.[2]

On the basis of these definitions and descriptions, the decision was reached to develop the curriculum in modules (or chapters) containing one or more behavioral objectives. Thus a set of guidelines (or a checklist) for the writing of behavioral objectives was developed. An acceptable behavioral objective would receive a "yes" answer to each of the following questions:

1. Does each behavioral objective state the task the student must perform?

2. Does each behavioral objective state how the student will perform the task?

3. Does each behavioral objective state the allowed time to complete the performance of the task?

4. Does each behavioral objective state the references which may or may not be used?

5. Does each behavioral objective state the location of the performance if it is other than the classroom?

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[2] *Ibid.*, p. 1.

6. Does each behavioral objective state specific equipment or classification of equipment which may be used?

7. Does each behavioral objective state the percentage of total responses that must be answered correctly?

8. Does each behavioral objective state the actual responses that will be acceptable?

9. Does each behavioral objective state the standard for judging the behavior?

10. Is each behavioral objective measurable by a third party?

In order for a student to accomplish the behavioral objective, the decision was made to write learning activities to accompany each behavioral objective. Once the objectives and activities were written, appropriate evaluation instruments and teacher materials were produced to correspond to the student materials.

Coordination of Personnel

The personnel involved in the production of a curriculum program included a director of curriculum development, one or more curriculum writers, one or more members of a research and evaluation team, one or more teachers, and one or more editors and proofers. The minimum number of personnel involved in the production of the curriculum program was five, excluding such personnel as secretaries, typists, and printers. The involment of personnel was organized in such a way as to provide maximum interaction, feedback, and double-checking.

As described in the next section of this study, "Identification and Validation of Content," the content was chosen and written by a teacher and a curriculum writer working together in constant interaction. The teacher served as the subject area specialist and provided all content information. The curriculum writer was responsible for asking the appropriate questions to secure the needed information and to organize the materials into an appropriate format, using writing skill to provide appropriate wording and clarity, and to avoid semantic problems.

During the writing process, other teachers in the cluster were often consulted for assistance. A chemistry teacher having over thirty years of industrial experience in chemistry was also asked to assist on several occasions.

As behavioral objectives were produced, they were checked by one or more of the other curriculum writers for clarity and measurability. They were then submitted to the research and evaluation team where one or more of the specialists in that area evaluated them on the basis of the guidelines listed previously. Each objective was marked by the research and evaluation team as "accepted" or "rejected." Those which were rejected were revised and corrected as needed and resubmitted until an "accepted" rating was received. All objectives were then carefully edited for grammatical construction, correct spelling, and correct punctuation before final typing. The editor then proofed the final typing before the objectives were used by the students and teacher.

Provision for writing time was made by the school district by using a staff development plan. Several hours were provided on a biweekly basis and full days were made available on several occasions. Additional work was done on a daily basis during the teacher's planning period. The school district also paid for the teacher's services in curriculum writing during the summer months and, on occasion, paid for classroom substitutes to provide the teacher with additional released time.

Identification and Validation of Content

With the teacher and curriculum writer assigned the task of choosing and writing the content for the metallurgy course, some decision had to be made as to the best way to proceed. For the purposes of this study and to accomplish the assigned task, it was decided that the course should be based upon concept-relationships or generalizations which were basic to the field of metallurgy. These would provide a basis for organizing the skills to be learned, for writing the goals, and for organizing and writing the behavioral objectives and the activities. Such a procedure also seemed the best way to accomplish the kind of curriculum which had been defined and described as the desired outcome.

A skills curriculum based on concept-relationships would also accomplish two other purposes. (1) It would provide a general foundation for all metalwork. This was important in that it would produce a course which could be used as a prerequisite to the other courses in the metal manufacturing cluster such as Machine Shop, Welding, and Sheet Metal. (2) It would provide the student with basic understandings in metalwork which could be transferred to any related metalworking jobs in industry.

As the concept-relationships were being identified and written, an advisory committee was formed for the purpose of validating the curriculum. The members of the Advisory Committee were chosen jointly by the school district and the local chamber of commerce. The Advisory Committee consisted of seven members whose names are listed in Appendix G. The concept-relationships were submitted to the committee for approval. At a general meeting of the committee, metallurgy teacher, and curriculum writer, approval was received with the inclusion of a few corrections and revisions. These were identified and made at the meetings. The revised concept-relationship statements appear in Appendix D. Before the meeting was adjourned, the committee members were requested to submit lists of skills related to the concept-relationships which would be appropriate to teach high school students and which were currently used in industry.

With the recommendations provided by the Advisory Committee and the help of the teacher, the skills for the course were identified. (See Appendix D.) Table IV, showing which skills were organized under the various concept-relationships, is in Appendix C.

Each skill was used as the basis for writing a behavioral objective. Each behavioral objective with its corresponding learning plan was considered a module or "chapter." At intervals where related modules were concluded, summary modules were provided in which the student would combine and apply the skills and understandings from the group of related modules.

After each behavioral objective was written and approved by the research and evaluation team, learning activities were written for each of the objectives. The purpose of the activities was to give the student a set of experiences which would enable him to accomplish the behavioral objective. The number of activities per objective varied from three to ten. The type of activities also varied depending on the objective. Such items as reading, field trips, demonstrations, lectures, daily tests, experiments, slide or film presentations, and many types of hands-on activities were used.

To test whether the student could accomplish the behavioral objectives, an evaluation instrument was written for each objective. Specific guidelines were established for these evaluation instruments to assure their quality. An acceptable instrument would receive "yes" answers to all of the following questions:

1. Does the evaluation instrument measure what it purports to measure?

2. Is the evaluation instrument free from ambiguities, faulty structure, or give-away responses?

3. Does the evaluation instrument demonstrate good grammatical construction?

4. Does the evaluation instrument clearly specify what responses are to be elicited?

5. Does the evaluation instrument measure representative behaviors specified in the behavioral objective?

6. Is the evaluation instrument independent of the behavioral objective for administrative purposes?

7. Is the evaluation instrument criterion-referenced so that it is measurable?

The instruments were written jointly by the teacher and the curriculum writer. Each evaluation instrument was submitted to the research and evaluation team as many times as necessary to receive an "approved" rating.

The final task involving the teacher with the curriculum writer was the development of the Teacher Implementation Plan. This section of the curriculum was written for use by the teacher only. In addition to the concept-relationship statements, answers for daily tests, and answers for the evaluation instruments, this section included notes and suggestions for the teacher concerning the lectures, demonstrations, and other types of activities necessary to implement the curriculum.

The Advisory Committee had previously participated in approving the concept-relationships and in recommending the skills to be taught, but when all parts of the curriculum were complete, the total curriculum was submitted to the Advisory Committee for validation. Recommendations from the committee concerning activities to be added or deleted, wording to be changed, and needed corrections were incorporated into the curriculum. The final approval of the Advisory Committee was then received.

Description of the Curriculum Materials

The features of the curriculum developed corresponded to the original definition of the curriculum desired; that is, stable in content and flexible in method. The metallurgy program developed in this study is an individualized course designed to assist the student to develop specific skills in the metal trades industry. The skills are presented in the following groups:

1. Identifying combinations of metals and alloys required for industrial functions.

2. Identifying processes of modifying metals.

3. Using destructive testing methods to analyze materials.

4. Using non-destructive testing methods to analyze materials.

5. Interpreting blueprint information.

6. Measuring dimensions, tolerances, and allowances.

7. Heat-treating metals and alloys to meet specifications.

8. Building and testing models to determine their load supporting capabilities.

9. Testing products to determine their life expectancy.

The student has two sets of options to exercise in completing the course. One set concerns the study of each module; the other relates to the order of the modules.

A module in the student materials may be considered the same as a chapter. The decisions within the module's learning activity sequence are to be made by the student in cooperation with the instructor. The student first reads the Statement of Behavioral Objective and decides between taking immediate evaluation or proceeding through the learning activities before evaluation. If the student is not successful in his evaluation, he needs to plan with the instructor for activities and experiences to strengthen him in his areas of weakness. When he is successful in performing the behavior in the objective, he proceeds to the next module.

Although there is a sequence of modules indicated by their arrangement in the student materials, it is not necessary that they be studied in that order. Again, the student has several options. He should work with the instructor to decide whether to (1) study the modules as sequenced, (2) rearrange the series, (3) study two or more modules simultaneously, or (4) omit certain modules not applicable to his personal or career purposes. The first option would be best for the student who is new in the field of metallurgy.

The order of modules and the order of activities within the module can be varied depending on factors in the local teaching situation such as age and previous experience of the student, time available, and the equipment and supplies available.

Student Materials

The student materials developed in this study[3] begin with an Introduction to the Student. This introduction provides the student with information about the course, options that are available, and how to use the curriculum materials.

Career competency goals are provided in very brief phrases and are the student's targets or goals to be

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[3]Dallas Independent School District, Materials Processing and Quality Control: Student Learning Plan(New York, 1975).

accomplished. The goals are stated in terms of industrial competencies.

The Statement of Behavioral Objective outlines what is expected of the student in working toward the target career competency goal. The objective is presented in a three-paragraph form.

Paragraph 1 is the behavioral outcome. This paragraph describes the behavior the student must exhibit to demonstrate that he has met the career competency goal.

Paragraph 2 is the statement of the conditions or limitations. This paragraph describes the circumstances under which the student must demonstrate his skill or knowledge. He is told what equipment he will use, how much time he will have, and what references, if any, he may use.

Paragraph 3 is the statement of the criteria of acceptable performance. This paragraph sets the standards for the student's work and tells him how well he must perform to complete the objective.

The Student Learning Plan is the section of each module which outlines the activities and resources needed to help the student master a skill or apply a concept. Not all possible activities and resources are suggested; not all suggested activities and resources are required. The student should work with the instructor to choose those activities and resources which will provide for his optimal growth in the study of metallurgy. A bibliography is provided at the end of the student materials.

Evaluation Instruments

The evaluation instruments developed in this study[4] were written so that there is one for each behavioral objective. Some evaluation instruments require written answers to show that the student has acquired the knowledge to accomplish the objective. Others require hands-on activities which demonstrate the student's proficiency in a particular skill. Each instrument, whether of the written or performance type, is criterion-referenced, telling how well the student must do in order to accomplish the objective. The student is therefore not competing with others for a grade on the objective, but is only competing with himself to see if he can accomplish a task according to established criteria of acceptable performance.

The evaluation instrument also lists the supplies, materials, and equipment which the student is permitted or required to use. A time limit is set and specific instructions are stated as clearly and briefly as possible as to what he is to do. The student is also told whether or not he is allowed to use references during the evaluation and, in some instances, what references he must use.

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[4]Dallas Independent School District, Materials Processing and Quality Control: Evaluation Instruments (New York, 1975).

In instances where the criteria consist of a long list of operational procedures to be performed, the student is allowed to follow the list in the behavioral objective unless the instrument specifically states that no references may be used, or unless the instructor feels that the memorization of that list of procedures is vital.

Instructor Materials

The curriculum materials for the instructor[5] begin with an Introduction to the Teacher. The introduction includes information concerning the rationale for the course, the course itself, the options available to the student and the teacher, the career competency goals, and the use of the curriculum.

The instructor's materials are organized by groups of related modules with a list of references at the end of each group of modules. Each section begins with a brief introduction explaining the purpose of the modules in that group. This is followed by the list of concept-relationship statements for that group of modules.

It is important to explain the use to be made of the concept-relationship statements. These statements were provided only in the instructor's materials for a definite reason. They should never be given to the student and

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[5]Dallas Independent School District, Materials Processing and Quality Control: Teacher Implementation Plan (New York, 1975).

certainly not used as material to be memorized by the student. Concepts are not "given" or "taught." They are acquired through a process. In order for a student to develop a concept, he must arrive at an understanding for himself through a discovery process. This process should be guided by the activities and questions designed by the teacher to help the student reach the "aha" of understanding the concept. (See Chapter I, "Background and Significance.") The student's way of wording the concept may be (or probably will be) considerably different from the way it appears in the instructor's materials.

Each section of the Teacher Implementation Plan contains instructions for implementing those activities which require some kind of explanation or for which additional information is provided for the instructor. Some of the learning activities such as reading assignments, observation of films, or field trips do not require any explanation to the instructor, and thus do not appear in the Teacher Implementation Plan. Instructions are also included for each evaluation instrument in that group of modules.

A concluding test is provided at the end of the last module. This test may or may not be used by the instructor depending on his decision within the regulations of his school district. The concluding test is a multiple-choice test designed to evaluate the student's development of concept-relationships in metallurgy.

A glossary of terms follows the concluding test. This glossary is included to clarify for the teacher the technical terms used in the curriculum. The definitions in this glossary are not intended for use by the students as they appear in the instructor's materials. The same approach should be used for definitions as for concept-relationships. As much as possible, the student should be allowed the experience of going through the process of defining terms rather than having them handed to him ready-made. This may not be possible in all instances and some basic definitions may have to be provided by the instructor in order to help the student get started. At the high school level, most students will have sufficient vocabulary and etymology to make a good start at defining terms on their own.

The instructor's materials conclude with a bibliography. The bibliography is the same as the one which appears in the student's materials except that it also includes a section of additional teacher resources which are not referenced in the curriculum, but which may be of benefit to the instructor in implementing the course.

CHAPTER III

ANALYSIS OF DATA

Instruments Used

Two instruments were used for this study. One was used by the Committee of Authorities to evaluate the concept-relationships and skills on which the metallurgy curriculum was developed. (See Appendix D.) The instrument consisted of a list of the sixteen concept-relationship statements and their sub-statements (making a total of seventy-six) and a list of the thirty-three skills available to the student in the course.

Each concept-relationship statement and sub-statement was rated "yes" or "no" as to its appropriateness at the high school level and "yes" or "no" as to its universal truth. Each skill statement was rated on a five-point to one-point scale as to its degree of usefulness in industry or its necessity as background material. A rating of "5" represented "extremely useful"; "4" was "very useful"; "3" was "useful"; "2" was "not very useful"; and "1" was "of no use." Appropriate spaces were provided for checking the ratings on both lists. Requests and spaces were provided for the addition of concept-relationship statements or suggestions for how to correct concept-relationship statements which were rated as "not universally true." Space was also provided for suggesting additional skills.

The other instrument was designed for a report from only one individual--the metallurgy instructor, as to the accomplishments of the students enrolled in the program. (See Appendix F.)

Results of the Survey and Use of the Data Collected

As stated in the methods and procedures section of Chapter I, a return of 75 per cent of the forms distributed to the Committee of Authorities was considered acceptable. Of the 20 forms, 16 were returned, or a total of 80 per cent. (See Appendix B.) Of the 16 returned, 9 were from members of industry and 7 were from vocational educators.

Examination of Table I reveals the responses on the section of the survey relating to skills. According to the criteria established in the methods and procedures section of Chapter I, none of the skills were deleted, and only one of the skills (Number 2--Select metals having the cubic arrangement required for industrial functions) fell in the category of being given careful consideration as to its revision or replacement. The decision was made to keep but change the skill statement. The rationale for the decision consisted of several aspects:

TABLE I

SUMMARY OF RATINGS OF SKILLS
BY COMMITTEE OF AUTHORITIES

Skill Number	Number of Ratings					Total No. of Ratings
	5	4	3	2	1	
1	7	3	5	1	0	16
2	3	4	4	3	0	14*
3	2	2	10	2	0	16
4	7	3	5	1	0	16
5	9	5	2	0	0	16
6	6	9	1	0	0	16
7	13	1	2	0	0	16
8	6	6	3	1	0	16
9	12	3	1	0	0	16
10	12	3	1	0	0	16
11	10	4	2	0	0	16
12	9	4	2	1	0	16
13	8	7	1	0	0	16
14	9	5	2	0	0	16
15	9	5	1	1	0	16
16	10	4	2	0	0	16
17	2	9	5	0	0	16
18	8	7	1	0	0	16
19	8	4	3	1	0	16
20	9	5	2	0	0	16
21	11	2	3	0	0	16
22	10	3	3	0	0	16
23	5	8	3	0	0	16
24	11	3	2	0	0	16
25	7	6	3	0	0	16
26	13	1	2	0	0	16
27	2	6	6	1	0	15*
28	3	2	10	1	0	16
29	0	7	7	2	0	16
30	7	4	4	1	0	16
31	2	7	6	1	0	16
32	4	5	7	0	0	16
33	4	6	5	1	0	16

*Numbers do not correspond to number of forms returned because of blanks left on rating sheets.

1. It was the only skill which received the required three low ratings established in the criteria.

2. The three committee members who gave the skill low ratings were all from industry.

3. As indicated by its position of "2" in the list of skills, the reason for its inclusion was for educational background material and not for direct use in industry.

4. As seen in the section on rating of concept-relationship statements, the use of the term "cubic arrangement" appeared to be somewhat confusing or misleading according to the Committee of Authorities.

5. The statement was therefore revised to use the term "atomic arrangement" rather than "cubic arrangement" and thus reads: "Select metals having the atomic arrangement required for industrial functions."

Examination of Table II reveals the responses on the section of the survey relating to the seventy-six concept-relationship statements. It is important to point out that the total responses in the "appropriate" columns and the total responses in the "universally true" columns did not always total sixteen (the number of forms returned). This was true because not all of the respondants rated every concept-relationship statement.

According to the criteria established in the methods and procedures section of Chapter I, concept statements rated by three or more members of the Committee of Authorities as "inappropriate" and therefore to be deleted were

TABLE II

SUMMARY OF RATINGS OF CONCEPT-RELATIONSHIP STATEMENTS BY THE COMMITTEE OF AUTHORITIES

Concept-relationship Statement Number	Appropriate		Universally True	
	Yes	No	Yes	No
1	15	1	14	1
1a	12	3	13	2
1b	12	3	13	2
1c	13	2	14	1
1d	14	1	15	0
1e	13	2	15	0
2	14	2	13	2
2a	15	1	15	0
2b	15	1	15	0
2c	12	2	12	2
2d	13	3	12	3
3	11	5	12	3
3a	13	3	12	3
3b	11	4	14	1
4	13	2	14	0
4a	13	2	13	2
4b	12	3	13	2
5	13	2	12	2
5a	14	2	13	2
5b	12	3	12	2
5c	12	4	12	2
6	16	0	15	0
6a	14	0	12	2
6b	15	0	12	2
6c	15	0	12	2
6d	12	2	5	9
6e	15	0	13	2
6f	13	2	8	7
7	13	2	14	1

TABLE II--Continued

Concept-relationship Statement Number	Appropriate		Universally True	
	Yes	No	Yes	No
8	14	2	13	2
8a	11	4	12	2
8b	10	6	9	6
9	15	0	13	2
9a	14	0	12	2
9b	14	0	14	0
9c	15	1	14	1
9d	16	0	15	0
9e	15	0	14	1
9f	15	0	13	2
9g	16	0	14	1
9h	12	1	10	3
10	15	0	13	2
10a	15	1	14	1
10b	15	0	15	0
10c	15	1	13	2
11	15	0	14	1
11a	14	1	14	1
11b	13	2	12	3
11c	16	0	15	0
11d	15	0	14	1
11e	15	0	15	0
12	16	0	10	5
12a	15	1	14	1
12b	14	1	14	1
12c	16	0	13	1
12d	15	0	12	2
12e	14	1	11	3
13	14	0	14	0
13a	15	0	15	0
13b	15	0	14	1
13c	15	0	14	1

TABLE II--*Continued*

Concept-relationship Statement Number	Appropriate		Universally True	
	Yes	No	Yes	No
14	15	0	13	2
14a	15	0	14	0
14b	15	0	15	0
14c	14	1	9	5
15	14	1	13	2
15a	13	2	10	5
15b	15	0	13	1
15c	15	0	13	2
16	15	0	14	1
16a	15	0	14	1
16b	16	0	14	1
16c	15	0	13	2
16d	15	0	15	0
16e	16	0	14	1
16f	15	0	15	0

numbers 1a, 1b, 2d, 3, 3a, 3b, 4b, 5b, 5c, 8a, and 8b. Removal of these eleven statements left a total of sixty-five statements to be used in the teaching of the course.

The criteria established also required the revision of some of these sixty-five statements which were rated by three or more members of the Committee of Authorities as "not universally true." The statements which required revision were numbers 6d, 6f, 9h, 11b, 12, 12e, 14c, and 15a. For revisions made in these eight statements, see Appendix E.

The information provided by the Committee of Authorities under the section of the rating form requesting information concerning making universally true statements of those which were rated "not true" provided the needed material for the revision of the eight statements. Several of the revisions were necessary as a result of the use of the term "cubic arrangement." This term was corrected as suggested by the committee to read "atomic arrangement" throughout the concept statements.

Also from the information provided by the committee, two additional statements were revised slightly for clarification even though they were not rated "not true" by the committee. These two statements are indicated by an asterisk (*) in Appendix E.

Appendix C is a table of the skills to be taught and the original concept-relationships with which they were associated. The removal of the eleven concept statements rated "inappropriate" for the high school level by the Committee of Authorities does not lessen the value of teaching the skills required for performance in industry. This was indicated by the high ratings received from the Committee of Authorities on the skills included in the curriculum. The change required is one of emphasis. The understandings of some of the concept-relationships were evidentally considered unimportant or too difficult by the committee members, and therefore should not be stressed in the curriculum. If, however, a student should come to some of these understandings in the attainment and development of the skills, so much the better. As seen by a comparison of the concepts deleted with Table IV in Appendix C, no skill taught was left without one or more concept-relationships on which it was based.

Only one member of the Committee of Authorities made specific recommendations as to skills and concepts which should be added to the curriculum. He suggested one concept and five skills. The concept was rejected on the basis that it was too complex for inclusion in a course designed for the high school level. Of the five additional skills recommended, one was already included in the activities of the module on heat treating. Three of the skills were considered to be appropriate for the college level, but not for high school. The final skill recommended was rejected on the basis of the extensive cost of the equipment required, although it was considered appropriate if such equipment could be attained.

Examination of Table III reveals how many of the students in the course attempted which of the 33 objectives and the number of those objectives they completed. The total number of students participating in the curriculum was 21. These students attempted a cumulative total of 374 of the 33 objectives as revealed in the distribution in Table III. Of the 374 attempted, only 85 objectives were

TABLE III

SUMMARY OF SUCCESS OF STUDENTS IN COMPLETING BEHAVIORAL OBJECTIVES AS REPORTED BY THE METALLURGY INSTRUCTOR

Number of Behavioral Objective (Corresponds to Skill Number)	Number of Students Attempting	Number of Students Completing	Number of Students Not Completing
1	20	13	7
2	9	7	2
3	20	14	6
4	9	7	2
5	9	7	2
6	17	14	3
7	9	7	2
8	8	5	3
9	9	8	1
10	10	10	0
11	9	9	0
12	9	8	1
13	7	7	0
14	7	7	0
15	7	5	2
16	20	20	0
17	20	20	0
18	20	20	0
19	20	20	0
20	9	4	5
21	9	7	2
22	9	6	3
23	9	4	5
24	9	7	2
25	9	7	2
26	9	5	4
27	16	13	3
28	15	13	2
29	7	7	0
30	8	4	4*

TABLE III--Continued

Number of Behavioral Objective (Corresponds to Skill Number)	Number of Students Attempting	Number of Students Completing	Number of Students Not Completing
31	9	4	5*
32	9	0	9*
33	8	0	8*
Totals	374	289	85

*These 26 were not completed because of lack of time at the end of the school year.

not completed. Of those 85, there were 26 not completed because of lack of time at the end of the school year.

Two aspects of Table III are important to notice. First, not all of the students attempted the same objectives or the same number of objectives. According to the design of the program, this is as it should have been. Individualization in such a course involves both time and content elements. Not all students needed or selected the same objectives. Since some worked faster than others, the number of objectives completed differed.

Second, Table III does not indicate the fact that some students had to repeat all or portions of some behavioral objectives before they completed them. Again, this is as it should have been. The repetition did not indicate total inability of the student nor inappropriateness of the skill. It simply indicated that he made mistakes, needed more information, or needed more practice. Since the criteria for his performance were established in advance and available to him, the student could see why he had not met the Criteria of Acceptable Performance and, with the help of the instructor, decide what needed to be done to meet those criteria.

CHAPTER IV

SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Summary

This study was designed to provide a model curriculum for high school metallurgy students based on skills and concept-relationships, and to evaluate the ability of high school students to complete behavioral objectives designed to teach these skills and concept-relationships. The evaluation of the skills and concept-relationships for the curriculum was accomplished through the ratings of the Committee of Authorities and the evaluation of student ability to accomplish the objectives through a summary report from the metallurgy instructor who used the model program.

The purposes of the study were:

1. To describe the developmental processes by which the model curriculum was derived.
2. To provide a model curriculum for high school metallurgy students.
3. To evaluate the basis of the content of the model curriculum.

A study of the related literature revealed a definite need for model curriculum programs. Especially was this found to be true concerning programs built on conceptual frameworks. Current educational trends which were researched and discovered to have sound and logical foundations were employed in the development of the curriculum program. Attention was also given to the relationship between learning activities and the development of concepts. The importance of the element of discovery on the part of the student was evident from the research. The teacher's role was found to be that of giving direction to learning by asking pertinent questions and designing appropriate learning activities.

The development of the curriculum program used as the basis for this study began with the establishment of a goal to produce career education curriculum materials which were appropriate at the high school level. The sources providing input for the programs to be offered (school district consultants, chamber of commerce members, members of the community, and students) included in their recommendations a program in metallurgy. After a delay of one year resulting from insufficient student requests for the program, the development of the metallurgy program was started. This study was made through the facilities of the Curriculum Dapertment/Career Education of the Dallas Independent School District.

Development of the program was based on a description of the curriculum outcome, which was established in advance.

From this description, the decision was reached to build the curriculum in modules (or chapters), each containing a behavioral objective and a student learning plan. A set of guidelines for the development of these modules was then established.

Numerous personnel were involved in the developmental process in order to provide feedback to the curriculum writer. This was also done in an effort to upgrade the quality of the curriculum materials above those in existence. Among the personnel were members of a research and evaluation team which checked each behavioral objective and each evaluation instrument to assure that they met the established criteria. The curriculum writer and the metallurgy teacher who worked together in constant interaction to produce the curriculum materials used staff development time and summer months for their work.

The content of the curriculum was validated twice; once by the Advisory Committee formed jointly by the school district and the local Chamber of Commerce, and once by the Committee of Authorities organized for the purposes of this study. The Advisory Committee first approved the concept-relationship statements as the basis for the course. The teacher and the curriculum writer then identified skills to be taught in connection with these concept-relationships. The Advisory Committee approved the skills and added some skills to the program. When the metallurgy program was complete, it was resubmitted to the Advisory Committee for final approval, which was received.

The Committee of Authorities for this study was selected to include members from industry and from vocational education. Sixteen of the twenty members of the committee returned the evaluation forms provided them. These forms provided the bases for several of the findings and conclusions of this study.

The curriculum materials which were produced and were subsequently described were published in three volumes. The student materials[1] contain the following parts:

1. Introduction to the Student
2. Modules 1-33
3. Bibliography

An evaluation instrument was provided for each module as may be seen in the published materials.[2] The instructor materials[3] contain the following parts:

1. Introduction to the Teacher

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[1]Dallas Independent School District, Materials Processing and Quality Control: Student Learning Plan(New York, 1975).

[2]Dallas Independent School District, Materials Processing and Quality Control: Evaluation Instruments(New York, 1975).

[3]Dallas Independent School District, Materials Processing and Quality Control: Teacher Implementation Plan (New York, 1975).

2. Instructions for learning activities and evaluation instruments for Modules 1-33
3. Concluding Test
4. Glossary
5. Bibliography

Findings

As related to Purpose 1, the description of the developmental process, it was found that such a process must have the commitment, backing, and financial support of the school district's board of trustees. It was further found that an increase in the number of personnel involved in developing a curriculum program provides the potential to produce materials superior to those produced by a single individual. The curriculum materials were found to be adequately validated by the use of an advisory committee knowledgable in the field of metalwork.

As related to Purpose 2, the provision of a model curriculum for high school metallurgy students, that curriculum was provided under the title Materials Processing and Quality Control and was taught by the metallurgy instructor at Skyline Career Development Center in Dallas, Texas. In response to the three questions formulated under Prupose 2, it is now evident that the student materials should contain a minimum of the following elements:

1. An introduction to provide information about the course, to outline the options available in the

course, and to give directions as to the proper use of the curriculum materials.

2. A sequence of learning modules, each containing a behavioral objective and activities to guide the student toward attainment of the behavioral objective.
3. A bibliography providing resource material to be used in the learning activities or as the criteria of acceptable performance for the behavioral objectives.

The evaluation instruments should be criterion-referenced, thus telling the student how well he must perform in order to accomplish the objective. The instructor materials should coincide with the student materials and the evaluation instruments and should include a minimum of the following elements:

1. An introduction to provide the same information as the student introduction as well as suggestions for the various ways in which the curriculum may be used successfully.
2. Instructions and notes for complex learning activities and instructions for the use of the evaluation instruments.
3. An optional concluding test which may be used according to the discretion of the instructor and the rules of his school district.

4. A glossary of terms to clarify the use of technical terms found in the curriculum materials.
5. A bibliography which includes all of the resources used by students in the learning activities plus additional manuals and books which may be helpful in implementing the curriculum.

As related to Purpose 3, the evaluation of the concept-relationships and skills forming the basis for the content of the curriculum, findings were associated with each of the three questions formulated under Purpose 3 as follows:

1. It was found that of the 76 concept-relationships stated, 64 were true as originally written according to the established rating criteria. (See Table II, pages 42-44.) It was also found that 64 of the 76 concept-relationships stated were appropriate for understanding by high school students according to the same criteria. (See Table II.) The list of 64 "universally true" concepts and the list of 64 "appropriate for the high school level" concepts were not identical. Therefore, 8 "not universally true" concepts were rewritten and 7 "universally true" concepts were deleted on the basis of being "inappropriate for the high school level." The remaining "not universally true" concepts were not rewritten because they

overlapped the "inappropriate" group and were deleted on that basis.

2. All of the 33 skills except one were rated by the Committee of Authorities as those being currently used in industry or necessary as background material for work in industry. The rationale for retaining the one skill receiving a low rating was that it was written using the wrong terminology. It was therefore reworded as suggested by the committee and retained in the curriculum.

3. From the report of the metallurgy instructor, the following information was determined. The 21 high school students in the metallurgy program had attempted a cumulative total of 374 of the 33 behavioral objectives and had accomplished a total of 289, or 78 per cent. Only 85 objectives, or 22 per cent, attempted were not completed, and 26 of these 85 were not finished because of a lack of time at the end of the school year.

Other findings related to the evaluation done to accomplish Purpose 3 were:

a. The content of the curriculum was based on a large majority of universally true concept-relationship statements. Evidence for this finding was that the model curriculum contained universally true concept-relationship statements in 64 of 76 instances. The necessary statements were revised so that the completed curriculum contains a total of 65 universally true statements validated by the Committee of Authorities. The remaining "not true" statements were removed.

b. The skills taught in the curriculum were those currently used in industry or those necessary as background material for work in industry. Evidence for this finding was that the model curriculum contained such skills in 32 of 33 instances according to the Committee of Authorities. The one exception was reworded and retained because of its value as background material.

Conclusions

Indications are that the findings of this study would support the following conclusions:

1. The curriculum produced and evaluated in this study is a model curriculum for the study of metallurgy at the high school level.
2. The curriculum developed in this study can be accomplished by high school metallurgy students.
3. A skills curriculum can be based upon concept-relationships which form the understandings necessary to teach the skills.

4. Curriculum programs for career education should be produced through the cooperative efforts of personnel representing industry and personnel representing the schools.

Implications

The value of such a model curriculum is found not only in its usefulness to high school metallurgy students, but also in its usefulness to educators as a model which could be replicated in the production of curriculum materials for other programs in both vocational and academic fields. The inplication seems apparent that this is one possible effective developmental pattern for producing a curriculum to meet student needs and industry requirements, although other developmental processes, either existing or not yet developed, may also be effective in accomplishing such an assignment.

Recommendations

Although this study has provided answers for the questions formulated, the following questions may provide a basis for additional study concerning the use of conceptual teaching and the use of behavioral objectives:

1. Of the teachers who use this model program, how many use it in connection with other materials or methods not included in the model? What are those materials and methods, and how effective are they?

2. Would research substantiate that an increase in either the speed of learning a skill, the speed of using a skill, or the accuracy of a skill occurred as a result of conceptual teaching?
3. Would transfer of learning of a metallurgical skill to a similar or related skill be increased or improved by the original skill having been learned as a result of conceptual teaching?

APPENDIX

APPENDIX A

PRELIMINARY GROUP TO INSPECT REPORTING FORMS

Bolen, Dr. Patsy
Facilitator, Curriculum/Career Education
Dallas Independent School District
Dallas, Texas

Easley, Mr. Glenn
Metallurgy Instructor
Skyline Career Development Center
Dallas Independent School District
Dallas, Texas

Harris, Mr. Paul
Director, Curriculum/Career Education
Dallas Independent School District
Dallas, Texas

APPENDIX B

COMMITTEE OF AUTHORITIES

Name Company or School Title	Street Address City, State Zip Code	Telephone Area Code
CO-CHAIRMEN		
McLeod, Dr. Pat N. North Texas State University Area Head, Vocational-Technical Education	P.O. Box 13707 Denton, Texas 76203	788-2202 817
Sorensen, Mr. Bob Dresser Industries Supt. of Metallurgical Research	P.O. Box 24647 Dallas, Texas 75226	331-3211 214
MEMBERS OF COMMITTEE		
*Belanger, Mr. Edward Plano High School Metal Trades Instructor	1517 Avenue H Plano, Texas 75074	424-5602 214
*Bernson, Mr. Al Peerless Manufacturing Company Assistant to the Vice President	2811 Walnut Hill Lane Dallas, Texas 75229	357-6181 214
Coorpender, Mr. Ray Denton High School Metal Trades Instructor	1002 Fulton Denton, Texas 76201	382-9611 817
*Dennis, Mr. Tommy E. Boswell High School Metal Trades Instructor	P.O. Box 79160 Saginaw, Texas 76179	232-0880 817
Farrier, Mr. Arthur W. Denison High School Metal Trades Instructor	1901 S. Mircek Ave. Denison, Texas 75020	465-2488 214

Gilder, Mr. W. D. Retired Metallurgical Consultant	7770 Meadow Rd., #101 Dallas, Texas 75230	363-7398 214
Goodman, Mr. John Ector Independent School District Director of Vocational Education	P.O. Box 3912 Odessa, Texas 79760	332-9151 915
Gray, Mr. Dan H. Turner High School Metal Trades Instructor	1600 Josey Lane Carrollton, Texas 75006	242-6402 214
Gross, Mr. John Carpenter Steel Company Metallurgist	2605 Freewood Dallas, Texas 75220	352-1771 214
Guilfoyle, Mr. Paul Timken Company District Manager	5151 Lakawana Dallas, Texas 75247	637-2170 214
Holbert, Mr. Al Continental Amsco Chief Metallurgist	1302 Alamo Lane Garland, Texas 75040	276-5151 214
Jackson, Mr. Gil Schill Steel Company Regional Manager	3835 Singleton Blvd. Dallas, Texas 75212	631-5053 214
*Miller, Mr. Robert Vacuum Heat-Treating President	P.O. Box 20526 Dallas, Texas 75220	357-0394 214
Moore, Mr. Jim Ling-Temco-Vaught NDT Specialist	510 Aspen Arlington, Texas 76013	266-5945 WK 214 277-2802 HM
Stokes, Dr. Vernon Tarrant County Community College Chairman, Metal Trades	South Campus Fort Worth, Texas 76119	534-4861 817
Tew, Mr. James Texas Instruments V. Chrmn. Am. Soc. for Qual. Cont.	10235 Maple Ridge Dr. Dallas, Texas 75238	238-4175 214

Williams, Mr. Gary Jorgenson Steel Company Metallurgist	P.O. Box 5025 Dallas, Texas 75222	741-1761 214
Woods, Mr. John Trimble Technical High School Machine Shop Instructor	1003 West Cannon Fort Worth, Texas 76104	332-7191 817

*Did not return materials

APPENDIX C

TABLE IV

CHART OF THE ASSOCIATION OF SKILLS TO CONCEPT-RELATIONSHIP STATEMENTS

Concept Statements	Skills
1 - 5	1 - 5 and 22 - 26
6 - 7	6 - 8
8 - 9	9 - 12
10	13 - 15
11 - 12	16 - 18
13 - 14	19 - 21
15	27 - 29
16	30 - 33

APPENDIX D

SURVEY FORM FOR SKILLS AND CONCEPT STATEMENTS

Name of Evaluator ______________________________

METALLURGY SKILLS

5 = Extremely useful
4 = Very useful
3 = Useful
2 = Not very useful
1 = Of no use

	Degree of usefulness in industry or Necessity as background material				
	5	4	3	2	1
1. Identify samples of metal elements	___	___	___	___	___
2. Select metals having the cubic arrangement required for industrial functions	___	___	___	___	___
3. Combine two metals having low melting temperatures	___	___	___	___	___
4. Identify steel samples by using a spark test	___	___	___	___	___
5. Identify combinations of metals and alloys required for industrial functions	___	___	___	___	___
6. Anneal welded and cold-formed parts	___	___	___	___	___
7. Associate grain structure with heat treatment	___	___	___	___	___
8. Identify processes of modifying metals	___	___	___	___	___
9. Perform hardness tests	___	___	___	___	___

		5	4	3	2	1
10.	Perform tensile, compression, and shear tests	___	___	___	___	___
11.	Perform impact tests	___	___	___	___	___
12.	Use destructive testing methods to analyze materials	___	___	___	___	___
13.	Locate defects with the dye penetrant system	___	___	___	___	___
14.	Locate defects with the magnetic particle system	___	___	___	___	___
15.	Use nondestructive testing methods to analyze materials	___	___	___	___	___
16.	Use blueprint information necessary to manufacture or inspect parts	___	___	___	___	___
17.	Evaluate machined and coated surfaces	___	___	___	___	___
18.	Interpret blueprint information	___	___	___	___	___
19.	Measure internal and external locations of machined parts	___	___	___	___	___
20.	Identify and use gauges	___	___	___	___	___
21.	Measure dimensions, tolerances, and allowances	___	___	___	___	___
22.	Anneal metals and alloys to meet specifications	___	___	___	___	___
23.	Apply proper media for quenching	___	___	___	___	___
24.	Harden metals and alloys to meet specifications	___	___	___	___	___
25.	Reduce hardness and increase toughness of metals and alloys to meet specifications	___	___	___	___	___

		5	4	3	2	1
26.	Heat treat metals and alloys to meet specifications	___	___	___	___	___
27.	Produce specimens of given mill-formed shapes	___	___	___	___	___
28.	Identify fabricated structural shapes	___	___	___	___	___
29.	Build and test models to determine their load supporting capabilities	___	___	___	___	___
30.	Compute allowable tolerances of parts	___	___	___	___	___
31.	Test materials for resistance to abrasion	___	___	___	___	___
32.	Perform corrosive tests on component parts	___	___	___	___	___
33.	Test products to determine their life expectancy	___	___	___	___	___

Please add below any skills which have been omitted that you feel should be a part of a high school course of this type.

METALLURGY CONCEPT-RELATIONSHIPS

Concept-Relationship Statement	Appropriate* Yes	Appropriate* No	Universally True Yes	Universally True No
1. The identification and classification of metals is determined by the number, size, and arrangement of the subatomic particles of the element.	___	___	___	___
a. Elements having three or less electrons in their outer shell and having positive valences are distinguished as metals.	___	___	___	___
b. Elements having five or more electrons in their outer shell and having negative valences are identified as nonmetals.	___	___	___	___
c. Elements having four electrons in their outer shell and capable of exhibiting either positive or negative valences are metalloids.	___	___	___	___
d. Subatomic structure of each metal element differs from every other element in number, size, and/or arrangement of particles.	___	___	___	___
e. The atomic weight of a metal is determined by the number and size of the subatomic particles present.	___	___	___	___
2. The subatomic structure of a metal determines its electrical, magnetic, thermal, and mechanical characteristics.	___	___	___	___

*at the high school level

	Appropriate Yes	Appropriate No	Universally True Yes	Universally True No
a. The electron structure of metals and alloys permits the conductance of heat and electricity.	___	___	___	___
b. The degree of conductivity is relative to the rate at which the electrons "flow" or move.	___	___	___	___
c. The degree of magnetism a metal or alloy will accept is relative to the amount of pairing or nonpairing of electrons.	___	___	___	___
d. The mechanical characteristics of metals are determined by the affinity of the atoms to one another in the pairing and sharing of electrons.	___	___	___	___
3. The cubic arrangement of atoms in the unit cell is responsible for the amount of resistance to movement within the unit cell.	___	___	___	___
a. Cubic arrangement is identified according to the ratio of atoms to space within a given area.	___	___	___	___
b. Cubic arrangement and space between the atoms is determined by the size of the atoms, their electron structure, and the ability to share electrons.	___	___	___	___
4. The orientation of metal crystals and their boundaries determine the ability of the metal to withstand opposing forces.	___	___	___	___

	Appropriate		Universally True	
	Yes	No	Yes	No
a. Each metal has a unique crystal arrangement determined by the combination of the cubic arrangement with the size of the atoms involved.	___	___	___	___
b. The resistance of a metal to internal shifting planes is proportionate to the strength of the bonds between atoms which join the unit cells.	___	___	___	___
5. Combined physical properties of metals bring about changes in one or more of the mechanical properties of the metals.	___	___	___	___
a. Selection of the elements and amounts of elements for alloying is made according to the desired mechanical properties.	___	___	___	___
b. Metal elements having like cubic arrangement and chemical valence are combined in a state of solution to achieve changed mechanical properties.	___	___	___	___
c. Metal elements having unlike physical properties are combined in a state of suspension to form compounds having changed mechanical properties.	___	___	___	___
6. The degree of change brought about in the mechanical properties of a metal or alloy varies according to the composition of the metal or alloy and the heating and cooling processes chosen to				

	Appropriate		Universally True	
	Yes	No	Yes	No
soften or harden the metal or alloy.				
a. Composition of the metal or alloy determines the combination of heating and cooling processes to be used.				
b. The temperature chosen for processing is determined by the metals or alloys present and by their amounts.				
c. The length of time the processing temperature is maintained for softening is determined by the degree of softness desired and the size of the part.				
d. The length of time the processing temperature is maintained for hardening is determined only by the size of the part.				
e. The rate of cooling for softening or hardening is determined by the degree of softness or hardness desired and by the material involved.				
f. The quenching medium is chosen according to the composition of the metal or alloy involved and the degree of hardness or softness desired.				

7. The processes involved in modifying metals to perform industrial functions are identified by relating the maximum stress to which the

	Appropriate Yes	Appropriate No	Universally True Yes	Universally True No
metal or alloy is to be subjected to a corresponding measurement of the mechanical properties of the metal or alloy.	___	___	___	___
8. Each of the mechanical properties of metals and alloys maintains a direct relationship to the atomic arrangement of the metal or alloy.	___	___	___	___
a. The ability of a metal or alloy to be shaped results from the ability of atoms to move and change places.	___	___	___	___
b. The strength of a metal or alloy is determined by the geometrical configuration of the cubic arrangement.	___	___	___	___
9. Measurement of the maximum amount of a mechanical property possessed by a metal or alloy requires the breaking of the bonds between the atoms of the metal or alloy.	___	___	___	___
a. Designations of the amount of a mechanical property possessed by a metal or alloy is relative to some other mechanical property or to an arbitrarily set standard.	___	___	___	___
b. Flexibility is measured by determining the ratio between the amount of linear movement available in the metal and the psi load required to establish a point of deformation.	___	___	___	___

	Appropriate		Universally True	
	Yes	No	Yes	No
c. Ductility is measured by determining the percentage of deformation a material will withstand without fracture.	___	___	___	___
d. Machinability is measured by determining the rate at which material can be removed with the rate stated as a percentage of an arbitrary standard.	___	___	___	___
e. Toughness is measured by determining the foot-pounds of impact required to sever a metal specimen.	___	___	___	___
f. Strength is measured by determining the amount of psi load required to cause a change in configuration of the metal.	___	___	___	___
g. Hardness is measured by determining a metal's resistance to deformation by a penetrator based on the indention made by the penetrator.	___	___	___	___
h. The continuum of the measurement of the mechanical properties of a metal or alloy is composed of overlapping designations of elasticity ranging from a maximum amount of flexibility through ductility, machinability, toughness, and strength to a maximum amount of hardness.	___	___	___	___
10. Defective areas in a metal or alloy are revealed by chemical, magnetic, X-ray, or ultrasonic methods.	___	___	___	___

	Appropriate		Universally True	
	Yes	No	Yes	No
a. Surface flaws in a metal or alloy are revealed through processes applied to make the defective area visually apparent.	___	___	___	___
b. Internal flaws in a metal or alloy are revealed when a defective area causes an interruption in the path of a wave of energy induced into the metal or alloy.	___	___	___	___
c. Abnormalities in a metal or alloy lessen the ability of the metal or alloy to perform the desired function.	___	___	___	___
11. Designation of a metal finish is based upon measurement of the unevenness of the surface.	___	___	___	___
a. The combination of the lay of the material with the waviness and roughness of the surface determines the unevenness of the finish.	___	___	___	___
b. The surface finish of a metal which moves in contact with another surface must be complimentary to the wearing properties of the surface which it contacts.	___	___	___	___
c. When the primary purpose of a finish is that of appearance, the texture needed is determined by the aesthetic judgment of the designer.	___	___	___	___
d. The texture of a surface finish produced for the primary purpose of having a				

	Appropriate Yes	Appropriate No	Universally True Yes	Universally True No
coating or plating applied is determined according to the coating or plating processes to be used.	___	___	___	___
e. Variations in roughness must not exceed specified tolerances of the part to avoid affecting the critical dimensions.	___	___	___	___
12. Coatings applied to metal surfaces change the appearance and finish of the surface and provide the metal with protection from corrosion.	___	___	___	___
a. Preparing a surface for a coating to be applied requires knowledge of the base metal and the coating.	___	___	___	___
b. The method of applying a coating to a metal surface is determined by the interaction of the size and material of the part with the purpose and type of coating to be applied.	___	___	___	___
c. Adherence of an applied coating to a metal surface is dependent upon the ability of the coating to form a bond to the base metal.	___	___	___	___
d. The texture of a metal finish is improved by coatings which fill the waviness and discontinuities of the metal surface.	___	___	___	___
e. Applied coatings provide protection for metal surfaces by placing an insulation between the metal and corrosive elements.	___	___	___	___

		Appropriate		Universally True	
		Yes	No	Yes	No
13.	A system of dimensional measurement for translating ideas into products requires standardization of units of length.	___	___	___	___
a.	Measurements allow distances to be reconstructed.	___	___	___	___
b.	The configuration and size of the part dictate the type of instrument to be used to measure the part.	___	___	___	___
c.	Correlation or mating of parts is dependent upon the accuracy of the measurement system.	___	___	___	___
14.	The size of two mating parts with given tolerances determines the allowance needed for proper fit.	___	___	___	___
a.	Allowances given on mating parts provide for variations in classes of fit.	___	___	___	___
b.	Limits placed on dimensions by tolerances tell the amount of variation in size permitted in the part.	___	___	___	___
c.	The equipment to be used to machine a part is chosen according to the accuracy specified in the tolerances.	___	___	___	___
15.	Changes in the structural shape of a metal or alloy bring about corresponding changes in the structural strength of the metal or alloy.	___	___	___	___

	Appropriate Yes	Appropriate No	Universally True Yes	Universally True No
a. An increase in structural strength resulting from a change in structural shape reduces the size and weight of the material required.	___	___	___	___
b. A change in the structural shape of a metal or alloy causes the lines of force to be redistributed within the metal or alloy.	___	___	___	___
c. Lines of force provide for a gain in structural strength when they are arranged so that opposing forces are distributed equally throughout the metal or alloy.	___	___	___	___
16. The reliability of a multi-part product is equal to the wearability of the weakest individual part.	___	___	___	___
a. Reliable products result from proper engineering and quality workmanship.	___	___	___	___
b. The wearability of parts is affected by the environmental conditions in which they operate.	___	___	___	___
c. Wearability is affected by the rate at which cycles of stress are applied and the resulting degree of friction.	___	___	___	___
d. Friction is decreased by applying substances that form a film on mating surfaces to reduce the unevenness of the surfaces.	___	___	___	___

	Appropriate		Universally True	
	Yes	No	Yes	No
e. The life expectancy of a product depends on proper use and regular maintenance.	___	___	___	___
f. Component interchangeability requires consistency in manufacturing processes.	___	___	___	___

Please state below how the concepts which are not universally true may be restated to make them true.

Please add any concept statements which you feel are vital to a high school course of this type.

____
Signature of Evaluator

Note: The statements in Appendix D are under copyright by the Dallas Independent School District, Dallas, Texas.

APPENDIX E

TABLE V

CHANGES IN CONCEPT-RELATIONSHIP STATEMENTS

Original Statement	Revised Statement
*4a Each metal has a unique crystal arrangement determined by the combination of the cubic arrangement with the size of the atoms involved.	Each metal has a unique crystal arrangement determined by the combination of the atomic arrangement with the size of the atoms involved.
6d The length of time the processing temperature is maintained for hardening is determined only by the size of the part.	The length of time the processing temperature is maintained for hardening is determined by the size of the part, the alloys involved, and the depth of hardness required.
6f The quenching medium is chosen according to the composition of the metal or alloy involved and the degree of hardness or softness desired.	The quenching medium and method of application are chosen according to the metal or alloy involved, the degree of hardness or softness desired, and the interaction of the metal or alloy with the quencing medium.
*9 Measurement of the maximum amount of a mechanical property possessed by a metal	Measurement of the maximum amount of a mechanical property possessed by a metal

Original Statement	Revised Statement
or alloy requires the breaking of the bonds between the atoms of the metal or alloy.	or alloy requires the breaking of the bonds between atoms along the planes of the metal or alloy.
9h The continuum of the measurement of the mechanical properties of a metal or alloy is composed of overlapping designations of elasticity ranging from a maximum amount of flexibility through ductility, machinability, toughness, and strength to a maximum amount of hardness.	Change in one of the mechanical properties of a metal or alloy results in a change in all of the other mechanical properties of that metal or alloy.
11b The surface finish of a metal which moves in contact with another surface must be complimentary to the wearing properties of the surface which it contacts.	For maximum wear, the surface finish of a metal which moves in contact with another surface must be complimentary to the wearing properties of the surface which it contacts.
12 Coatings applied to metal surfaces change the appearance and finish of the surface and provide the metal with protection from corrosion.	Coatings applied to metal surfaces change the appearance and finish of the surface and provide the metal with a degree of corrosion protection and/or wear resistance.
12e Applied coatings provide protection for metal surfaces by placing an insulation between the metal and corrosive elements.	Applied coatings provide a degree of protection for metal surfaces by placing an insulation between the metal and corrosive or abrasive elements.

Original Statement	Revised Statement
14c The equipment to be used to machine a part is chosen according to the accuracy specified in the tolerances.	The accuracy specified in the tolerances and the production rate required dictate the equipment to be used to machine a part.
15a An increase in structural strength resulting from a change in structural shape reduces the size and weight of the material required.	The size and weight of the structural material required to support a load is reduced when the lines of force are equally distributed.

*These statements had changes made for the purpose of clarification, not as a result of their being rated incorrect by the Committee of Authorities.

APPENDIX F

COPY OF FORM FOR INSTRUCTOR'S REPORT

Name of Instructor ______________________________

Number of students enrolled in metallurgy course __________

Number of Behavioral Objective	Number of Students Attempting	Number of Students Completing	Number of Students Not Completing
1	___	___	___
2	___	___	___
3	___	___	___
4	___	___	___
5	___	___	___
6	___	___	___
7	___	___	___
8	___	___	___
9	___	___	___
10	___	___	___
11	___	___	___
12	___	___	___
13	___	___	___
14	___	___	___
15	___	___	___
16	___	___	___
17	___	___	___
18	___	___	___
19	___	___	___
20	___	___	___
21	___	___	___
22	___	___	___
23	___	___	___
24	___	___	___
25	___	___	___
26	___	___	___
27	___	___	___
28	___	___	___
29	___	___	___
30	___	___	___
31	___	___	___
32	___	___	___
33	___	___	___

APPENDIX G

LIST OF MEMBERS OF CLUSTER
ADVISORY COMMITTEE

Name Company	Street Address City, State Zip Code	Telephone Area Code
Bernson, Mr. Al Peerless Mfg. Company	2811 Walnut Hill Lane Dallas, Texas 75229	357-6181 214
Gipson, Mr. Willard Texas Instruments	Box 6015, Station 260 Dallas, Texas 75222	238-2769 214
Jackson, Mr. Gil Schill Steel Company	3835 Singleton Blvd. Dallas, Texas 75212	631-5053 214
McHone, Mr. Roy Almanco, Inc.	5125 Lawnview Dallas, Texas 75227	388-0438 214
Salmons, Mr. Fred Gardner-Denver Company	4400 Hatcher Dallas, Texas 75210	428-1561 214
Sorensen, Mr. R. K. Dresser Industries	P.O. Box 24647 Dallas, Texas 75226	331-3211 214
Tew, Mr. James Texas Instruments	10235 Maple Ridge Dallas, Texas 75238	238-4175 214

APPENDIX H

TABLE OF CONTENTS FROM
MATERIALS PROCESSING AND QUALITY CONTROL:
STUDENT LEARNING PLAN*

CONTENTS

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