DOCUMENT RESUME

ED 196 343 HE 013 306

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TITLE	An Analysis of Construction Curricular Elements: A Pilot Study and Model Data Base for a Construction Curricula Planning and Resource Guide. Technical Report.
INSTITUTION	University of Southern Mississippi, Hattiesburg.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	SED-76-18870
PUB DATE	Aug 77
NOTE	149p.: Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Education, College of Education, University of Northern Colorado. Construction Curricula Planning and Resource Guide published January 1979.
AVAILABLE FROM	University of Southern Mississippi, Southern Station, Box 5137, Hattiesburg, MS 39401
EDRS PRICE	MF01/PC06 Plus Postage.
DESCRIPTORS	Bachelors Degrees; *College Curriculum; *Construction Industry; *Construction Management; *Curriculum Evaluation; *Curriculum Guides; Higher Education; *Job Skills; Job Training; Occupational Surveys; Pilot Projects; Questionnaires

ABSTRACT

The perceptions of experienced contractors regarding elements of a construction curricular guide at the baccalaureate level that was recommended by the education committee of the Associated General Contractors (AGC) were studied. The curriculum is designed to prepare individuals for the construction industry. Sixty-three employees of Colorado AGC member firms completed the survey instrument. Based on the findings, the following conclusions were drawn: (1) respondents found it difficult to look beyond their own particular job responsibilities in evaluating the importance of elements of the curricular guide; (2) respondents attached a higher level of importance to elements that were related to their academic background; (3) the length of construction experience does not appear to have a significant influence on perceptions of element importance; (4) the response to work experience as an alternate source of instruction for construction-oriented elements indicates that classroom instruction for these elements has only partially been accepted by industry personnel; and (5) while eight elements were found to be substantially less important than all other elements, the original construction education guidelines are essentially as valid now as when they were developed. The findings are illustrated by statistical tables, and procedures used to select the study population, develop the questionnaire, and analyze the results are described. A sample questionnaire is included. (SW)

Technical Report

AN ANALYSIS OF CONSTRUCTION CURRICULAR ELEMENTS

A Pilot Study and Model Data Base
for a
Construction Curricula Planning
and Resource Guide

Project Director

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NATIONAL SCIENCE FOUNDATION PROJECT SED76-18870

Technical Report Published August 1977,
Construction Curricula Planning and Resource Guide,
January 1979

DEC 12 1980

PREFACE

The primary objective of this project was to develope design criteria for construction education curricula at the baccalaureate level, utilizing input from the industry practitioner. The project was divided into two segments, (1) a technical report and analysis of curricular elements to develope a model data base, and (2) a curricular planning resource guide, which attempts to quantify the elements for inclusion into a model curriculum.

Since the technical report was also prepared as a doctoral dissertation, the organization methodology and statistical analysis were accomplished under the strict guidance and scrutiny of an academic committee, at the same time synthesizing extensive input from contractor education committee members and staff members of AGC-Colorado.

The population sample of contractor personnel utilized in the investigation represented a varied segment of the industry, but because of the magnitude of the total industry, did not include reference to residential construction or several types of specialized construction processes, eg: marine, electrical or mechanical. The investigator found such diversity of educational needs that further study is recommended for [illegible]ential and mechanica

Quantification of desired curriculum elements into semester credits was not undertaken in the technical report primarily because of the difficulty in determining precise time units to many curricular elements. Many of the elements are already in accepted and traditional time units, such as: Algebra (3 semester credits). Inherent in such programs is the need for flexibility in "packaging" concepts into courses to meet the specific goals of program or institution. The planning and resource guide attempts to place concepts in appropriate component groups which may be further "packaged" by an individual program into a specific course.

Many face to face discussions with construction professionals and educators form the conceptual basis of this technical report and resource guide. The investigator found many divergent ideas concerning construction education, but no disagreement on the concept or need for the product - a constructor. This report will hopefully add data and thought to the educational foundations of construction, which will also serve to provoke discussion, debate and then further development of this evolving academic discipline.

UNIVERSITY OF NORTHERN COLORADO

Greeley, Colorado

The Graduate School

AN ANALYSIS OF CONSTRUCTION CURRICULAR ELEMENTS

A Dissertation Submitted in Partial Fulfillment
of the Requirement for the Degree of
Doctor of Education

James W. Young

College of Education
Department of Educational Administration

Summer Quarter, 1977

ABSTRACT

Young, James W. "Analysis of Construction Curricular Elements." Published Doctor of Education dissertation, University of Northern Colorado, 1977.

Purpose

The purpose of this study was to explore the perceptions of experienced constructors regarding elements of a construction curricular guide recommended by the education committee of the Associated General Contractors in 1967. More specifically, the study was designed to ascertain: (1) the relative level of importance experienced constructors place on each of the elements of the curricular guide; (2) if element instruction should be acquired from sources other than an undergraduate construction program; (3) if constructors identify elements not included in the original guidelines; (4) if academic background and length of construction experience influence the perceptions of constructors toward the construction curricular elements.

Procedures for the Study

An _ex post facto_ design was selected for this study of the perceptions of experienced constructors regarding elements of a construction curricular guide. Participants were limited to field and project management personnel with baccalaureate degrees.

Sixty-three employees of Colorado AGC member firms completed the survey instrument.

To determine the relative importance of each element, the mean and standard deviation was computed and rank ordered. Mean values for level of importance were obtained by equating: "No importance" to 0; "moderate importance" to 1; "substantial importance" to 2; and "essential" to 3. Respondents selected an alternate source of instruction if the element was judged not appropriate to undergraduate instruction.

The influence of academic background on perceptions of element importance was tested by T-test of difference of means. The relationship of academic background to perceptions of element importance with experience controlled was tested by chi-square test of significance.

The data were analyzed with the assistance of the "Statistical Package for the Social Sciences" computer program.

Findings

(1) The influence of academic background on perceptions of respondents was significant on 31 percent of the elements. (2) With experience controlled, the relationship of academic background to perceptions of element importance was significant on only 13 percent of the elements. (3) Respondents attached greater importance to elements closely related to their responsibilities. (4) Only eight

elements were perceived by even a sizeable minority of the respondents as more appropriately acquired from sources other than an undergraduate program. (5) No element received sufficient negative response to exclude the element from the original guidelines for undergraduate construction programs.

Conclusions

Based on the findings of this study, the following conclusions were drawn: (1) Respondents found it difficult to look beyond their own particular job responsibilities in evaluating element importance. (2) Respondents attached a higher level of importance to elements which were related to their academic background. (3) The length of construction experience does not appear to have a significant influence on perceptions of element importance. (4) The response to work experience as an alternate source of instruction for construction oriented elements indicates that classroom instruction for these elements has only partially been accepted by industry personnel. (5) While eight elements were found to be substantially less important than all other elements, the conclusion may be drawn that the original construction education guidelines are essentially as valid now as when they were developed.

Recommendations

It is recommended that: (1) Based on the apparent influence of academic background, construction program advisory committees should be comprised of persons with differing academic backgrounds. (2) The study should be replicated with a population drawn from upper levels of management to determine if their perception of element importance is comparable to perceptions expressed in this study. (3) The role and place of required work experience prior to graduation should be studied. (4) The study should be replicated in differing geographic locations and with construction firms belonging to other industry associations. (5) In light of the minority response to alternate sources of element instruction, the education committee of the AGC should consider development of additional guidelines for inclusion of co-op (or internship) programs in the undergraduate programs, use of industry seminars as supplementary undergraduate instruction, and development of guidelines for graduate level construction courses.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to the many individuals who contributed valuable assistance in the conducting of the study and writing of the report. The author is especially grateful to his major advisor, Dr. Arthur R. Partridge, not only for his thoughtful criticism and guidance, but also for his patience and willingness to take time out of a busy schedule for many long distance consultations. The author would also like to thank the other members of his doctoral committee, Dr. John Dietz, Dr. Kenneth Hogan and Dr. Donald Montgomery, for their valuable comments and suggestions.

A special thanks goes to Professor Wesley Baldwin of the University of Southern Mississippi for his expertise in computer programming and to Dr. Colen Boutwell for providing a sounding board to the author's writing. Additional thanks to Professor Kenneth Ricard of Colorado State University for his help in development of the bio-data instrument.

Of major importance was the cooperation of the Associated General Contractor chapters in Colorado for their assistance in obtaining the data upon which this report is based. A special thanks to Mr. Duke Nielsen, Education Director of the AGC of Colorado, Builders Chapter and to Mr. Jay Lower, assistant Executive Director of the Colorado Contractors Association for their help in the distribution of the survey instrument.

To the people who gave of their time for the clerical work: Murray Woolf, who keypunched the data cards; Ann Poole, who typed many rough drafts; and Nancy Brown, who provided the finished manuscript.

Finally, the author wishes to express his appreciation to his family, and particularly to his wife, Jinny, for their love, understanding and patience during the long course of this study.

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CHAPTER I

DEVELOPMENT OF THE CONSTRUCTOR[1]

Nature of the Construction Industry

The business of construction represents a multiplicity of anomalies in the American industrial world. Contrary to typical business operations, the contractor[2] moves to the construction site, sets up a "factory," hires a working force, produces "one of a kind," dismisses the employees, closes down the factory, and moves to the next project he has contracted to manufacture. Each project operation presents new production problems, new groups of production employees, and a complete new system of controls for management of the project.

Further, unlike the major auto makers or electronic data manufacturers, the largest contractor organization has less than

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[1] Constructor: a responsible master of that discipline which comprises the whole of the construction process as well as the essential parts thereof, possessing such skills founded on systematic knowledge acquired through prescribed education and refined by experience, or earned equivalently as a recognized practitioner, who initiates, develops, produces, delivers, and services in whole or essential part.

[2] Contractor: refers to the total construction organization operating as a business entity.

one percent of the total construction market.[1] The largest contractor by total dollar of contracts in 1975 exceeded 6.8 billion dollars, while the 400th contractor in size had under 24 million dollars in contracts in the same year.[2] Engineering News Record reported thirty-one percent of the work constructed in 1975 was accomplished by the top 400 construction firms. The remainder of the construction dollars expended in 1975 was by thousands of small one-owner organizations.

Historically, while industry data indicates construction is one of the country's largest industries, employing 15 of every 100 workers; there are indications of high risk -- both financially and technically -- in the construction industry.[3] Engineering News Record reported an average of 45 to 55 construction company failures per week in the United States during 1975. Low working capital requirements and poor licensing and pre-qualification procedures make it easy for many unqualified persons to enter the contracting field. Bonding companies report the primary causes of company failure are inadequate management procedures and lack of financial controls. Another characteristic of the American construction industry

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[1] "The ENR 400," Engineering News Record, April 15, 1976, p. 66.

[2] "The ENR 400," Engineering News Record, April 15, 1976, p. 80.

[3] "Building Slump Lingers; Gains Seen for '77," Engineering News Record, January 22, 1976, p. 42.

is its slowness in adopting known industrial management techniques in manpower planning and utilization, time planning and scheduling systems, and materials handling techniques long used by the typical manufacturer. For example, while premanufactured brick panels are available, the typical constructor is placing bricks in a wall one at a time, at a pace less than that of 30 years ago, and in the same manner as 200 years ago.

Accelerated building costs, however, have dictated increased industry efforts to improve capabilities in systems building, construction techniques, construction equipment design and utilization, and the computerization of cost control and scheduling.

The traditional contractor of several decades past came up from the crafts after years of journeyman training (generally carpenters) or as graduates of conventional engineering programs. With minimal sophistication and a great deal of hard work and ingenuity, many "constructors" succeeded. However, technological advances in building systems, advanced management tools, and greater emphasis on control of costs have created an increased demand for highly qualified technical and managerial personnel by the industry. Bonny relates the following requirements for this "new breed" of contractor:

> Courage and optimism and willingness to work are no longer enough to assure success in contracting. The new breed of contractor and all of his staff, as he grows larger and spreads geographically, must have knowledge

> and great competence in many fields. He must understand how to choose and organize his staff. He must know how to command. . . get the financing. . . engineering and estimating must be understood. . . the strategy of bidding. . . accurate and detailed costs. . . insurance. . . labor relations and public relations. . . . No longer is it possible to run a construction company "by guess and by God" with a little luck.[1]

Construction Management

The successful constructor (one who completes the work on time and makes a profit) has balanced and interfaced a series of controllable functions and a variety of uncontrollable factors. The acquisition of new construction contracts is in one sense controllable in that estimates and bids can be produced. However if the bid submitted is not lowest, the project will not be available to construct. Weather, for example, is an uncontrollable factor of a possible disastrous magnitude, unless the superintendent or project manager has planned ahead for alternate activities, adjustments in crew sizing, and the modification of scheduling for remaining activities. Cost control is a function that can be planned in an orderly manner; labor relations on the job is largely unpredictable and difficult to control. To coordinate the many different functions

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[1] J. B. Bonny, ed., Handbook of Construction Management and Organization (New York: Van Nostrand Reinhold Company, 1973), p. 2.

and factors inherent in construction requires a flexible, skillful management team of specialists working toward a common goal: to construct at a profit.

The organization is largely determined by the type of work done, contractural system used, and qualifications of personnel. Several examples of construction organization operational systems are: (1) a general contractor who does very little sub-contracting, (2) a general contractor who subs out most of the work (sometimes referred to as a broker), (3) a design-build contractor who contracts for all design phases and the construction, with varying degrees of sub-contracting, and (4) the construction manager, who may be a direct representative of the owner and be involved from design through construction, and who may not do any construction with his own forces.

Contractors, regardless of operational type, have a field supervisory group and a home office organization handling overall project management, estimating and bidding functions, accounting and purchasing. Although firms vary greatly in gross income, the number of staff personnel involved will not vary in the same proportion. A typical contractor may have 6 to 12 projects under way, a

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[1] Definition: The process of marshalling money, men, materials, and equipment against time, weather, and human nature to accomplish the act of construction. ASC 1966.

staff of 7 to 20, and an annual gross income varying from $500,000 to $100,000,000.[1]

The field organization is headed by a Superintendent who is responsible for job-site control of the project. He has the authority to hire or fire the labor force and coordinates all sub-contractor activities. Depending on project size, several staff positions may be assigned: assistant superintendent responsible for segments of the work; project engineers responsible for cost control, scheduling, and shop drawings; field engineers responsible for field layout, materials expediting, quality control, and material estimates. Hired for this single project are journeymen from several specialty areas (masons, ironworkers, painters, etc.) and a foreman for each of the crafts. This work force will vary in size as the job manpower needs are determined during the life of the project.

The Project Manager has overall control of the project and handles contract administration; he monitors and attempts to control costs, and serves as project liaison between the Owner and Architect. A Project Manager may be responsible for several projects or a single large project. He may also be responsible for bidding of new work, if the company does not have an estimating

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[1] J. J. O'Brien and R. G. Zilly, eds., Contractor's Management Handbook. (New York: McGraw-Hill Book Company, 1971), p. 3-4.

department. The field force reports to the Project Manager through the job Superintendent.

Within the company structure are support functions of accounting, purchasing, equipment maintenance, and general overall operations control through the chief executive officers. The construction organization has no standard profile, nor are position titles and job descriptions common to all of the industry. Accounting methods, estimating procedures, and business acquisition techniques differ greatly between companies. Common to the industry, however, are the basic conceptual processes of determining the probable cost of a project from a set of drawings and specifications, bidding or negotiating a contract, and organizing a field manufacturing system to produce the project.

The uniqueness of construction operations requires management and technical persons with qualities noted by the AGC in the preamble to the construction education guidelines:

(1) The human understanding to be able to work with all types of people.
(2) The discipline to think and reason logically.
(3) The technical ability to visualize and solve practical construction problems.
(4) The managerial knowledge to make sound decisions and implement them on a prudent economic basis.
(5) The facility to communicate these decisions clearly and concisely.
(6) The professional stature to provide dynamic leadership in the construction industry and the community.[1]

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[1] Associated General Contractors, "Educational Goals and Recommended Construction Curricula for the Construction Industry," Washington, D. C., 1967.

Education of the Constructor

The need for uniquely educated persons for construction was recognized by some segments of the industry and by educators in the early 1950's. In 1951, University of Mississippi Professor of Civil Engineering F. H. Kellogg proposed, as he called it, major surgery on the then current civil engineering curriculum to prepare graduates in engineering to be more than technicians in construction. Professor Kellogg suggested that most senior design courses be replaced with specific construction subjects and even courses "for those who intend to work with people, . . . particularly instruction requiring writing and thinking in words rather than in pictures, numbers and symbols.[1]" W. A. Klinger -- contractor, former president of the Associated General Contractors (AGC), and active proponent of education and training programs for construction -- proposed a new degree program for construction in 1956.[2] Essentially a fifth year on top of a civil engineering degree program, Klinger's recommendations included management courses, technical construction courses, and general business accounting. Also recognized by Klinger was the fact that only one major institution had a

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[1] F. H. Kellogg, "The Construction Curriculum in Civil Engineering," Civil Engineering Bulletin, February, 1951, p. 9.

[2] W. A. Klinglez, "Construction Education: Industry Leader Proposes 5-Year College Curriculum," The Constructor, January, 1956.

degree in construction engineering: national engineering organizations were just beginning to study the problem of education for construction.

A survey of contractor members of the AGC in 1961 concluded that contractors did, in fact, want an emphasis in construction management, even if advanced structural design and certain other courses had to be omitted. However, this survey concerned itself with civil engineering education only, and while contractors responding to the survey questions felt that "construction was essentially a management function," they still preferred an engineering degreed person.[1]

Degree programs in "building construction" existed prior to World War II. The oldest continuously operating program, University of Florida, started in 1935. Other programs were initiated after World War II with the encouragement of Johns-Manville Corporation, a building materials company. Johns-Manville's interest was to "encourage young people to enter the building industry."[2] However, the industry generally indicated an attitude of "sub-professional" toward such non-engineering degree curricula.

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[1] W. A. Klingler, "What Do Contractors Want in Construction Education?", The Constructor, August, 1961.

[2] K. D. Knievel, "History of Industrial Construction Management at Colorado State University and A Comparative Study of Contemporary Programs." (Masters Thesis, Colorado State University, 1965), p. 14.

The national education committee of the AGC began discussions on recommended construction curricula in approximately 1965. A sub-committee composed of construction company executives produced a goals statement which stated:

> Increasingly, the Construction Industry is coming to realize that it will be served best by personnel specifically educated and trained in the managerial and scientific techniques necessary to meet the ever-increasing demands of this rapidly changing technological age. Few industries have more diversified personnel requirements. Professional engineers, business managers, technicians and skilled craftsmen, together form its manpower framework. Probably no other industry is so beset by recurrent personnel shortages at all levels. It is more than obvious that expanding training of manpower is one of construction's most pressing needs.[1]

Finally completed in 1967, this statement and recommended curricula guidelines were circulated to all AGC members and interested institutions. While these guidelines were significant because of being "first," the development process was conducted by a very small segment of the total construction industry. The problem still remains: What are the significant and desirable elements in a construction curriculum?

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[1] Associated General Contractors, "Educational Goals and Recommended Construction Curricula for the Construction Industry," Washington, D. C., 1976.

Purposes of the Study

The purpose of this study was to explore the perceptions of experienced constructors regarding previously developed elements[1] of a construction curricular guide developed by an education committee of a national construction association between 1963 to 1967. More specifically, the study was designed to answer the following questions:

1. What level of importance do selected experienced constructors place on each of the elements listed in the curricular guide?
2. Are curricular elements listed which present day constructors feel should be obtained from sources other than an undergraduate program in construction?
3. Are curricular elements identified as essential to undergraduate curricula that were not included in the original guidelines?
4. Does the academic background or length of construction experience influence the perceptions of experienced constructors toward the construction curricula elements of an undergraduate program?

Guidelines established in the mid-1960s remain as the only available nationally distributed recommendations for construction programs in the developmental stages. With the many changes in industry occurring over the past decade, there is reason to question the applicability of the guidelines in the present time frame. There

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[1] Definition: Elements -- For the purpose of this study, an element will designate the smallest single subject area as listed in the AGC Construction Curricula guidelines.

is also reason to believe that field and operational personnel may view with a totally different perspective required competencies, as compared to the viewpoint of top management.

Movement Toward Accreditation

The proliferation of construction programs in recent years at the baccalaureate level suggests the need to re-evaluate the make-up of existing curricular guidelines. The Construction Education Directory (AGC, 1974) listed 93 colleges and universities offering undergraduate and/or graduate degree programs or options within degree programs in construction. This is an increase of forty-eight schools since 1969.[1] The Associated Schools of Construction (ASC) has a 1977 membership of fifty-one, with several applications pending. This organization represents only construction degree programs at the baccalaureate level. Annual surveys by the ASC from 1966 to 1976 show that total enrollment increased from 2,043 students to 6,301 students, and graduates receiving B.S. degrees increased from 350 in 1966 to 1,264 in 1975.[2]

While growth in construction education continues, the following conditions exist indicating a need for this study:

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[1] Construction Education Directory (Washington, D.C.: The Associated General Contractors, 1974), p. 1.

[2] Associated Schools of Construction, "Minutes of the eleventh general meeting of the Associated Schools of Construction," Monroe, Louisiana, 1975. (Mimeographed).

1. Little formal research has been undertaken to investigate and validate requirements for a baccalaureate degree in construction.
2. The existing curricula guidelines are over ten years old.
3. Contractors, while aware of the desirability of construction graduates, are concerned about the uniformity of programs.[1]
4. Development of accreditation procedures for construction education is currently dependent on out-dated data.

Several researchers over the past decade have investigated various aspects of construction education. In 1969, Caldwell (University of Florida) surveyed academic programs in construction throughout the United States. Caldwell reported on one basic problem of construction programs -- identification:

> The building construction department is located in one of two colleges or schools in the majority of institutions. Of the twenty-one institutions included in this study it was found that the department is located in the College or School of Architecture in twelve instances and in the College of Engineering in five. Of the remaining, two are in Schools of Business and Administration, two in Industrial Arts, and one in the College of Agriculture.[2]

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[1] Interviews with contractor members of construction education committees over a six-year period, 1969-1975, by the researcher.

[2] Wofford T. Caldwell, "A Study of the Curriculum in Building Construction at Institutions of Higher Learning Throughout the United States" (unpublished Master's thesis, Florida State University, 1964), p. 31.

Knievel essentially supported the above findings and noted the lack of faculty with doctorates, indicating that in 1965 it was not possible to earn a doctorate in construction.[1] While Knievel did not attempt to place values on the inclusion or exclusion of subject areas, he did compare course offerings at Colorado State University and seventeen other schools. A primary finding was the inconsistency in types of course areas, with the exception of general education (English, social sciences, etc.) and the most basic of engineering courses.

A survey of Associated Schools of Construction (ASC) members in 1966 essentially substantiated the findings of Caldwell and Knievel. The ASC survey divided the curricula into five academic areas and had participating schools assign their courses to the various categories. The most apparent aspect of this seventeen-school study was the non-uniformity of offerings. For example, the range of basic sciences offered was from a low of 11.9 percent to a high of 32.5 percent of total curriculum credits. Other areas of applied sciences, management, and humanities were just as varied.[2] Such variances can be understood when it is remembered that no general

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[1] Knievel, p. 32.

[2] Associated Schools of Construction, "Report of Curriculum Study Committee," by Frank Orr, Chairman, Auburn University, 1967.

curriculum guidelines existed during the development of the participating schools.

A later curriculum comparison study under the auspices of ASC included a greater number of schools. The curriculum components in that study were the same as the AGC recommended guideline components, in an attempt to compare programs against the guidelines. Many of the same general characteristics of earlier studies appeared in this 1973 ASC study. A wide range of courses was listed under such components as "construction," "management," or "science." The percent distribution of required courses in construction, for example, ranged from a low of 21 percent to a high of 41 percent. Under the management component, the percent distribution of required courses ranged from a low of 10 percent to a high of 28 percent.[1] The AGC recommendation for each of these two areas is 15 percent and 16 percent, respectively. No part of these reported studies included an industry needs assessment or placed a "value" on particular curricular elements. These two ASC studies pointed out to educators and industry persons alike the lack of standard programs or even basic knowledge, specific knowledges, or competencies required by constructors.

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[1] Associated Schools of Construction, "Report of Curriculum Study Committee," Thurman Potts, Chairman, Northeast Louisiana University, 1973.

Some educators have attempted to identify these elements by field surveys among construction contractors. For a study of construction education at Purdue University in 1973, Moss had industry practitioners rank academic topics, skills required by graduates, and knowledge expected in a construction graduate. Six senior level construction executives from the same metropolitan area gave a value of 0 to 3 to each element from a predetermined list. The mean values were then rank ordered. These data were then used to formulate several proposed curriculum models.[1]

More recently a senior undergraduate student of Iowa State University mailed questionnaires to approximately 100 graduates and their employers to determine their opinions of specific courses and the overall effectiveness of the construction engineering curriculum. Specific courses were listed, and graduates and employers were asked their opinions on each course. Comments from employers included the statement, ". . . Construction engineers are much better prepared for construction than are civil engineers."[2]

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[1] D. D. Moss, "Knowledge and Skills Expected in a Construction Graduate," Unpublished report presented at meeting of Joint Committee for Construction Education, Purdue University, August 1972.

[2] L. L. White, "Report on the Effectiveness of the Construction Engineering Curriculum at Iowa State University," The American Professional Constructor, 1974, 2(2), 5-14.

Concurrent with the several studies reported, ASC and the American Institute of Constructors (AIC) proceeded to develop accreditation procedures for construction education. The American Council for Construction Education was incorporated and presented a proposal for formal recognition to the Council on Post-Secondary Accreditation (COPA) in early September of 1976. For the present time, ACCE has been content to utilize curriculum components and percentages as formulated by the AGC and used by the ASC. For the first time in the development of education for construction, all major industry associations have joined to support accreditation efforts by ACCE. However, there is still no real consensus by industry and educators as to the required curricular elements that will produce the desired "constructor," capable of meeting the needs of this complex industry.

Study Limitations

The magnitude of the construction industry in the United States is such that no single description, picture or research study can adequately begin to cope with this complex body of industry associations, company organizations, and construction procedures. There is need, then, to focus on a group of constructors which represents the industry. The following limitations were placed on this study to maintain a manageable range of personal contact with the participants, and to better understand the scope of work by the contractor organizations.

Limitation Number 1: Participants were selected from member construction firms of the Colorado Chapter of the Associated General Contractors of America. The study was concerned with development of educational elements by an AGC committee which has continued to function, bringing to individuals in AGC member firms an awareness of educational opportunities and needs. In addition, the 131 firms of the two AGC Chapters in Colorado represented a cross section of contractor operations in general construction, utility, and heavy-highway construction. These firms also represented a range of dollar construction volume, and varying sizes of management staffs. It can be reasonably assumed that this group represented the contractor members of the AGC.

Limitation Number 2: Participants were selected from staff and salaried positions, with primary responsibilities in field operations and office technical and management functions. The highest level of responsibility of a participant selected for this study was that of Project Manager. Corporate level executives have often indicated that much of their working time is spent in community affairs, politics, and other activities outside of and away from daily project operations. For this reason, personnel below the corporate level were selected as participants.

Limitation Number 3: Only persons with college degrees qualified as participants. The terminology and basic concepts used in the construction of the AGC guidelines are related to college and university curricular procedures. Therefore, awareness of these procedures was essential to the respondents' understanding of this study.

Limitation Number 4: Participants were selected with a minimum of one year construction experience. One year's experience was considered minimum to develop an awareness or understanding of construction procedures.

CHAPTER II

PROCEDURES FOR THE STUDY

This study investigated attitudes and perceptions of experienced constructors toward construction curricular elements developed by an industry association in the early 1960's. These curricular elements were re-evaluated by field and middle management constructor personnel employed by companies having membership in the same association which developed the original list of curricular elements.

Selection of Constructor Participants

The base population from which participants were selected were employees of member firms of the two Colorado chapters of the Associated General Contractors of America. These two chapters represent general building contractors, utility construction, heavy and highway contractors and some industrial construction. Member firms range in size, indicated by the yearly dollar volume, from under one million dollars to over 120 million dollars. The researcher's prior association with these firms indicated a high utilization of degreed personnel in staff positions, particularly from engineering and construction management disciplines. Executive and staff personnel have been active in state and national AGC affairs over the past decade, with particular emphasis in education and training programs of the association.[1] The operational area of these construction firms varied from a twenty-five mile radius of Denver to nationwide. Most companies had home offices along the Colorado front range. This area represents the largest concentration of construction firms in the central Rocky Mountain states. With the assistance of the executive staff of each AGE chapter, membership lists were reviewed to eliminate firms known to have no operational personnel or projects underway; to eliminate firms doing business only in the far western section of Colorado; and to eliminate firms which had no personnel that could be categorized within the study parameters. As stated in the limitations of the study, the participants were to have:

1. Baccalaureate degree.
2. Minimum one year construction experience after graduation.
3. Major responsibilities in field, project or office management.

Data with respect to firms contacted and the number responding is presented in Table I.

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[1] The AGC of Colorado, Building Chapter, Inc., employs a full-time educational director. The Colorado Contractor's Association assigns educational functions to the assistant director of the chapter.

TABLE I

PARTICIPATING CONSTRUCTION FIRMS

Firms	Membership	Deleted	Contacted	Responded
AGC of Colorado Contractors	65	12	53	23
Colorado Constructors Association	85	42	43	11

Executive officers of the AGC member construction firms were contacted in person or by phone, with the assistance of the education director of the AGC chapter office. The study objectives were outlined to the executive and if a positive response was received the executive was asked to identify participants that were within the study parameters. Some executives were reluctant to identify all potential participants in their firms, and in fact, some executives did not know or remember which persons had degrees. For this reason, it was impossible to determine the total potential number of participants. The final composite number of persons agreeing to participate was determined to be 125 degreed, staff personnel.

Approximately half of the questionnaires were delivered in person to the chief executive of the construction firm or a member of the management staff. The remainder were mailed directly to a chief executive, with an additional letter of introduction. Sample letters and the survey instrument are included in Appendix B.

Sixty-five of the 125 survey instruments were returned by the deadline of September 15, 1976. These responses represented 35.4 percent of the 96 construction firms asked to participate in the study. Although there is no precise data to support or deny the contention that the participating personnel are associated with firms ranging from small dollar volume to large dollar volume, it is believed that the respondents represent a fair cross-section of commercial construction contractors.

Design of the Survey Instrument

The primary purpose of the study was to determine the perceptions of experienced constructors toward educational elements developed for baccalaureate construction education programs by the AGC committee on Construction Education. These perceptions were analyzed in relation to the following variables:

(a) baccalaureate degree of the respondent

(b) length of construction experience after graduation.

Respondents were also requested to recommend new elements and to select one of three alternatives of element instruction if the listed element was not appropriate to an undergraduate curriculum.

The instrument was designed in two parts: (a) biographical data on the respondent, and (b) a Likert-type scale format for response to the 63 elements. The complete survey instrument is included in Appendix C. The bio-data form included questions concerning:

1. Name of present employer
2. Type of construction performed by the company
3. Title which best describes respondent's current position
4. Years of work experience in respondent's current position
5. Years of work experience after graduation
6. Year of graduation from undergraduate degree program
7. Type of undergraduate degree program
8. Name of institution from which degree was received
9. Graduate level courses taken
10. Type of graduate degree
11. Has the respondent taken a continuing education course?
12. Is the respondent registered as an Architect or Professional Engineer?

The distributional characteristics of this bio-data were compiled in the form of frequency distribution tables, with appropriate summary statistics.

The second segment of the survey instrument included the list of construction curricular elements, divided into three sections: (1) Construction and Management Elements, (2) Basic Sciences and Engineering--Basic and Applied, and (3) Socio-Humanistic Studies. The list of elements used in the study was an interface of two recommended construction elements lists, one for building construction and one for heavy highway construction. The AGC Education Committee decided in 1972 there was no real difference between the two original separate lists and combined the recommended guidelines into one recommendation for purposes of simplicity. No elements were deleted unless there were duplications.

To give greater clarity or better understanding of terminology, the researcher expanded several of the elements used in the original list. For example, the AGC list used the word "graphics," but did not indicate if mechanical or architectural graphics, or both, were desirable. The survey instrument included both types of graphics. Construction cost accounting was added to supplement the term "accounting." The term "quantity takeoff" was added to expand on the term "cost estimating." To determine if an academically higher level of mathematics and physics was desired, the elements "differential equations" and "engineering physics" were added to the list used in the survey instrument.

After each of the three sections, several blank spaces were included to permit writing in recommended elements.

To the left of each element, space was provided to check one of the four levels of importance as perceived by each respondent. The columns were headed: (0) No Importance, (1) Moderate Importance, (2) Substantial Importance, and (3) Essential. Each respondent was asked to indicate the level of importance that he attached to each element as it related to the level of importance for inclusion in an undergraduate construction curricula. To provide the respondent an alternate choice for source of instruction, three columns were provided at the right of each element: (1) Work Experience, (2) Non-degree Special Course, and (3) Graduate Program. A fourth column was provided to indicate that the element was not needed in construction. The selection of alternate sources of instruction categories was based on experience of the researcher in construction education and in consultation with experienced constructors.

The format of this study has been based on prior work related to determining technical competencies and performance levels desired by industry. In 1969, Maness assessed the perceptions of industry as to the need for curricular elements termed "integrated circuits."[1] Maness indicated the desirability of limiting the number of choices when industry persons are asked to respond to the questionnaire-type studies.

In a study of vocational agriculture teachers, Oades[2] requested each respondent to determine a performance level and to indicate the source of each technical competence. Five levels of performance perceptions and seven sources of instruction were used.

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[1] Maness, M. T. "A Critical Analysis of Integrated Circuits With Implications for Industrial Teacher Education Programs," (Unpublished doctoral dissertation, University of Northern Colorado, 1969).

[2] Oades, John Douglas. "Occupational Experience and Technical Competence of Vo-Ag Teachers," (Unpublished Ph.D. Dissertation, Colorado State University, 1976).

Bio-Data Analysis

The survey instrument requested each participant to indicate the major type of construction his company performed. Table II indicates the frequency of construction firm type in each of the ten categories listed.

TABLE II

PRIMARY TYPE OF CONSTRUCTION PERFORMED BY RESPONDENT'S EMPLOYERS

Type	Frequency	Percent
1. High-Rise Commercial	0	0
2. Commercial	26	41.3
3. Institutional	0	0
4. Heavy-Highway	14	22.2
5. Highway	2	3.2
6. Utility	6	9.5
7. Industrial	1	1.6
8. Commercial-Utility	2	3.2
9. Commercial-Industrial	10	15.8
10. Other types	2	3.2

Since many construction firms are diversified, a single word description of the type of construction performed was difficult. Participants were asked to indicate their secondary type of construction performed by the respondent's employer. Table III indicates the frequency of secondary type of construction performed by respondents' employers.

TABLE III

SECONDARY TYPE OF CONSTRUCTION PERFORMED BY RESPONDENT'S EMPLOYERS

Type	Frequency	Percent
1. High-Rise Residential	2	3.2
2. Commercial	2	3.2
3. Institutional	8	12.7
4. Heavy-Highway	16	25.3
5. Highway	1	1.6
6. Utility	5	7.9
7. Industrial	8	12.7
8. Commercial-Utility	5	7.9
9. Commercial-Industrial	9	14.2
10. Other types	7	17.5

Positions Held by Respondents

Participants were asked to indicate the primary and secondary job titles which best described their current company responsibility. Job titles used in the survey instrument were selected with the aid of industry consultants to reflect large and small company organizations.

Several respondents from small construction companies used the title of "Vice President." The researcher, after a personal interview with the respondents, determined that the day-to-day responsibilities were involved primarily with day-to-day project management. As a result, the respondent's title of "vice president" was recoded as "project manager."

Table IV presents the frequency of response by position title.

TABLE IV

JOB TITLES WHICH BEST DESCRIBE CURRENT POSITION OF RESPONDENT

Position	Frequency	Percent
1. Field Engineer	1	1.6
2. Assistant Superintendent	1	1.6
3. Project Engineer	8	12.7
4. Superintendent	5	7.9
5. Estimator	13	20.6
6. Scheduler	0	0
7. Cost Control	0	0
8. Project Manager	31	49.2
9. Officer Manager	1	1.6
10. Other Titles*	3	4.8

*Other titles included: Chief Estimator and Office Engineer, and Vice President.

Undergraduate Degrees of Respondents

The respondents were asked to indicate the undergraduate baccalaureate degree received. Table V presents the frequency for each of the degree titles listed. Four respondents indicating "other" were reassigned to a category most closely associated or related, i.e., English Literature recoded as Humanities; Architectural

Engineering as 5 Year Architecture; and Construction Technology as Building Construction. The above degrees were received from twenty-seven different colleges and universities as indicated by the respondents on the survey instrument.

TABLE V

UNDERGRADUATE DEGREE OF RESPONDENT

Type	Frequency	% of Total
Architecture 5 Year	5	7.9
Business	6	9.6
Construction-Building	5	7.9
Construction-Engineering	1	1.6
Construction-Management	21	33.3
Engineering-Civil	21	33.3
Engineering-Electrical	1	1.6
Engineering-Mechanical	1	1.6
Science	1	1.6
Humanities	1	1.6

Construction Experience of Respondents

Respondents indicated their length of construction experience in terms of the years of experience since graduation and the number of years' experience in their current position. Table VI reports summary data for each category.

TABLE VI

CONSTRUCTION EXPERIENCE OF RESPONDENTS

	Frequency	Mean	Std. Dev.	Range
Years' Experience Since Graduation	63	10.17 yrs.	7.99	29
Years' Experience In Present Position	63	4.94 yrs.	5.95	29

The total data are reported in Appendix D for construction experience since graduation and in Appendix E for years of experience in respondents' current positions.

The construction experience of respondents listed by academic degree is indicated in Table VII.

Post-Baccalaureate Education

To determine the extent of education beyond the undergraduate degree, questions were asked concerning graduate courses, graduate degrees and continuing education courses. Table VIII presents summary data concerning these responses.

TABLE VII

CONSTRUCTION EXPERIENCE SINCE GRADUATION LISTED BY ACADEMIC DEGREE

Years of Experience	Frequency		
	Construction	Engineering	Other
1	3	0	0
2	4	0	0
3	3	2	0
4	6	0	1 (Science)
5	3	2	0
6	3	1	0
7	4	2	1 (Business)
8	0	1	0
9	0	1	0
10	1	1	2 (Business English)
11	0	1	0
12	1	0	1 (Architecture)
13	0	0	1 (Business)
14	1	1	0
15	0	0	0
16	0	0	0
17	0	1	1 (Business)
18	0	2	0
19	0	1	0
20	0	1	1 (Business)
21	0	0	0
22	0	1	0
23	0	0	2 (Architecture)
24	0	1	1 (Architecture)
25	0	1	0
26	0	1	0
27	0	0	0
28	0	0	0
29	0	0	0
30	0	2	0
Sub-totals	29	23	11
		Total Respondents:	63

TABLE VIII

POST-BACCALAUREATE EDUCATION OF RESPONDENTS

Type of Coursework	Frequency	Percent of Total
Coursework at the Graduate Level	Yes: 15	23.8
Graduate Degrees:		
MBA	0	
MS	5	7.9
Ph. D.	0	
None	58	92.1
Continuing Education Courses	Yes: 33	52.4

Professional Registration

Professional Registration has not been a prerequisite for contractor operations. However, with a high degree of engineering educated construction persons as potential respondents, the survey sought to determine the extent of registered persons in the study population. Table IX presents the frequency of registered persons.

TABLE IX

PROFESSIONAL REGISTRATION

	Frequency	Percent
Professional Engineers	6	9.5
Architects	1	1.6
No Registration	56	88.9

Procedure for Data Analysis

The research design utilized in this study was ex post facto. Kerlinger states that:

> Ex post facto research is systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulatable. Inferences about relations among variables are made, without direct intervention from concomitant variation of independent and dependent variables.[1]

The independent variables of this study consisted of the respondents' academic background and length of construction experience. The dependent variables studied in this investigation were the ratings of importance of each element as perceived by experienced and degreed construction personnel employed by member firms of two Colorado chapters of the AGC.

Relative Importance of Elements

To determine the relative importance of each of the seventy-one elements as perceived by the sixty-three respondents, the means and standard deviation were computed and rank order established. Mean values for level of importance were obtained by equating: No Importance to "0"; Moderate Importance to "1"; Substantial Importance to "2"; Essential to "3".

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[1] Fred H. Kerlinger, Foundations of Behavioral Research, (Chicago: Holt Rinehart and Winston, Inc., 1973), p. 379.

Influence of Academic Background

The influence of academic background on the perceptions of respondents toward the curricular elements was studied by testing the following null hypothesis:

> HYPOTHESIS H_{o1}: There is no difference between constructors with academic degrees in construction and constructors with academic degrees in engineering in their perceptions of the importance levels of the construction curricular elements.

The corresponding alternative hypothesis is stated:

> HYPOTHESIS H_{a1}: Constructors with academic degrees in construction and constructors with academic degrees in engineering differ in their perceptions of the importance levels of the construction curricular elements.

The null hypothesis was tested using T-tests of significance on each element to determine if perceptual differences exist between respondents of differing educational backgrounds. The 0.05 level of significance was used to test the hypothesis.

Experience as a Controlling Factor

The relationship between academic background and perceptions of curricular element importance when controlled by length of construction experience was investigated with the use of contingency table analysis and summarized by chi-square test of significance. Respondents were divided into two groups by education: engineering education and construction education. These groups were further divided by length of construction experience: less than nine years of experience and greater than nine years of experience.

The following null hypothesis was tested to determine if a systematic relationship existed between the two variables:

> HYPOTHESIS H_{o2}: There is no difference between constructors with academic degrees in construction and constructors with academic degrees in engineering, and the length of construction experience as it relates to their perceptions of the importance levels of the construction curricular elements.

> The corresponding alternative hypothesis is stated:

> HYPOTHESIS H_{a2}: Constructors with academic degrees in construction and constructors with academic degrees in engineering differ in their perceptions of the importance levels of the construction curricular elements, in relation to length of construction experience of the respondent.

The following model illustrates the three-dimensional table utilized to investigate the relationships stated in the null hypothesis. Element One, Orientation, is used as an example. In the first table of the contingency table analysis, the controlling factor of 1 to 9 years of experience is examined.

ELEMENT ONE: Orientation

GROUP: Education
CONTROLLING FOR: Experience Less than 9 years

(Table One)

Group	Level of Importance					
	0	1	2	3		
Engineering Education	3	1	3	2	9	Count
	33.3	11.1	33.3	22.2	25.0	Row Pct
	42.9	25.0	27.7	14.3		Col Pct
	8.33	2.8	8.3	5.6		Tot Pct
Construction Education	4	3	8	12	27	Count
	14.8	11.1	29.6	44.4	75.0	Row Pct
	57.1	75.0	72.7	85.7		Col Pct
	11.1	8.33	22.2	33.3		Tot Pct
	7	4	11	14	36	Column Tot
	19.4	11.1	30.1	38.9	100	Percent

Chi Square = 2.077
3 degrees of freedom
Significance = .556

In the second two-dimensional table, the relationship between academic groups is examined by changing the controlling factor of experience to respondents with greater than eight years.

ELEMENT ONE: Orientation

GROUP: Education
CONTROLLING FOR: Experience 9 or greater

Group	Level of Importance 0	1	2	3		
Engineering Education	0	5	9	4	18	Count
	.0	27.8	50.0	22.2	66.7	Row Pct
	10	83.3	81.8	44.4		Col Pct
	.0	18.5	33.3	14.8		Tot Pct
Construction Education	1	1	2	5	9	Count
	11.1	11.1	22.2	55.7	33.3	Row Pct
	100.0	16.7	18.2	55.6		Col Pct
	3.7	3.7	7.4	18.5		Tot Pct
	1	6	11	9	27	Column Tot
	3.7	22.2	40.7	33.3	100.0	Percent

Chi Square = 5.886
3 degrees of freedom
Significance = .117

The critical value of chi square = 7.82 with 3 degrees of freedom at the 0.05 level of significance.

The printed output of the computer program were summarized with the chi-square statistic and probability.

The chi-square test of significance was used to determine whether a systematic relationship existed between the variables of education and level of curricular element importance when controlled by length of construction experience. Norman H. Nie, in the manual for "Statistical Package for the Social Sciences," writes:

> If no relationship exists between two variables in the sample under study, then any deviations from the expected values which occur in a table based on randomly selected sample data are due to chance. While some small deviations can be reasonably expected due to chance, large deviations,

> i. e., large values of chi-square, are unlikely. Since we do not know what the actual relationship is in the universe, we interpret small values of chi-square to indicate the absence of a relationship, often referred to as statistical independence. Conversely, a large chi-square implies that a systematic relationship of some sort exists between the variables.[1]

Alternate Sources of Element Instruction

Three categories of instruction are included in this study: (a) work experience, (b) non-degree special courses, (c) graduate programs. Respondents were asked to check an alternate source of instruction if the element was important to construction, but should not be included in an undergraduate program. Results were reported by comparison of percentages of response for individual items.

Recommended New Elements

The curricular elements listed in the original survey instrument were developed over ten years ago, with no new additions in the intervening time. With apparent changing construction procedures, contract systems and newer computerized cost control techniques, respondents were invited to recommend additional education elements to meet the changing conditions in construction. The identification of new curricular elements as recommended by the respondents is

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[1] N. H. Nie, C. H. Hull, J. G. Jenkins, K. Steinbrenner, D. Bent, Statistical Package for the Social Sciences, 2nd edition. (McGraw-Hill Book Company, New York: 1975), pp. 224.

listed by academic areas of basic sciences and engineering, construction and management, and humanities and social sciences.

The data for this study were analyzed with the use of the "Statistical Package for the Social Sciences" (SPSS) computer program. The basic distributional characteristics of the variables were examined through the sub-program "Frequencies." Investigation of the relationships between variables was accomplished through the use of the sub-program "Crosstabs." The comparison of sample means was accomplished through the use of the sub-program "T-Test."

Summary

The purpose of Chapter II was to describe procedures used to select the study population, development of the survey instrument, bio-data analysis and data analysis procedures.

Employees of member firms of the two AGC chapters of Colorado were used as population base of 125 experienced constructors, from which 63 responded to the survey instrument. Analysis of the bio-data indicated that commercial construction (41 percent) was the primary type of construction performed by respondents. Heavy-highway construction was performed by 27 percent of the respondents' employers. Almost half of the respondents (49 percent) listed their job title as project manager, followed by estimator (21 percent) and project engineer (13 percent).

One third of the respondents' academic degrees were in construction management and one third in civil engineering. The remainder of the academic degrees ranged from other construction and engineering degree titles, architecture, and business.

The researcher utilized sub-programs of the "Statistical Package for the Social Sciences" (SPSS) for computation of one-way frequency distributions, mean differences, and contingency table analysis.

CHAPTER III

PERCEPTIONS OF EXPERIENCE CONSTRUCTORS

A decade has elapsed since constructor members of an AGC education committee developed and distributed the construction curricular guidelines. This study investigated the perceptions of present-day experienced constructors toward elements of the AGC guidelines. Chapter II describes the data-gathering instruments, methods of research, and analysis of respondent bio-data. The purpose of Chapter III is to present the data concerning perceptions of experienced constructors with relation to level of element importance, relationship between academic backgrounds, and length of construction experience to perceptions of element importance, and to examine alternative sources of element instruction.

Relative Importance of Elements

Elements[1] listed in the construction curricular guidelines recommended by the AGC were developed by a committee of construction practitioners whose primary responsibilities were in

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[1] Elements numbered from 1 to 30 are related to construction technology, management and project administration. Elements numbered from 31 to 60 are concerned with mathematics, science, and engineering theory and design. Elements numbered from 61 to 71 are concerned with socio-humanistic studies and electives.

overall company management. Participants selected for this study have major responsibilities in field operations and project management in commercial, utility and heavy-highway construction. Sixty-three constructors responded to this study.

The distributional characteristics of responses to the level of importance scale for each of the 71 elements were summarized by computing the mean and standard deviation. The relative importance of each element within the total group was determined by rank order. The rank order of elements is presented in Table X, with raw data response of respondents reported in Appendix F, Frequency Distribution of Respondent's Perceptions of Level of Importance by Elements.

Mean values are equated to a numeric scale of 0 to 3, corresponding to the four levels of importance. The approximate grouping of elements around a particular level was assumed from the closeness of the computed mean value to the fixed number value of the level of importance. The approximate distribution of elements by mean values within the four levels of importance is indicated in Table XI.

TABLE X

RANK ORDER OF CONSTRUCTION CURRICULAR ELEMENTS

Number	Elements	Means	Std. Dev.	Rank
55	Construction Surveying	2.67	.622	1
2	Specifications & Drawings	2.59	.754	2.5
65	Oral Communications	2.59	.687	2.5
49	Fund. of Structural Design	2.43	.665	4
48	Properties of Construction Materials	2.33	.803	5
41	Algebra	2.32	.912	6.5
42	Trigonometry	2.32	.876	6.5
5	Quantity Take-off	2.30	.815	8.5
50	Structural Design: Wood, Concrete, Steel	2.30	.795	8.5
12	Project Scheduling & Control	2.27	.883	10.5
47	Mechanics of Materials	2.27	.883	10.5
54	Concrete Form Design	2.25	.782	12
4	Cost Estimating	2.24	.817	13
61	English Composition	2.22	.812	14
57	Surveying: Earthwork	2.19	.895	15
56	Engineering Surveying	2.08	.938	16
66	Technical Report Writing	2.06	.931	17
36	Graphics: Architectural	2.03	.915	18
3	Construction Contracts	2.09	1.011	19
46	Statics & Mechanics	2.00	1.016	20
13	Construction Economics	1.98	.975	21
1	Orientation into Construction	1.95	1.022	23
51	Soil Mechanics	1.95	.811	23
14	Cost Control & Analysis	1.95	1.053	23
43	Analytic Geometry	1.92	.955	25.5

TABLE X (Continued)

Number	Elements	Means	Std. Dev.	Rank
53	Foundation Engineering	1.92	.848	25.5
27	Construction Contract Law	1.87	1.054	27
67	Professional Ethics	1.84	.987	28
9	Building Materials	1.83	.793	29
28	Organization & Management	1.81	1.075	30
35	Graphics: Mechanical	1.78	.923	31
23	Personnel Management	1.75	1.046	32.5
32	Engineering Physics	1.75	1.015	32.5
26	Business Law	1.73	.901	34
71	Directed Electives	1.71	.990	35.5
37	Descriptive Geometry	1.71	.905	35.5
11	Construction Safety	1.70	.994	37.5
64	Logic	1.70	.994	37.5
30	Building Codes	1.67	.933	39
70	Electives (Undirected)	1.60	1.100	40
10	Construction Equipment	1.57	.945	41.5
25	Labor Relations	1.57	1.042	41.5
31	General Physics	1.56	.980	43
6	Bidding Procedures	1.54	1.044	44
8	Project Organization & Operation	1.52	1.148	45.5
44	Calculus	1.52	.997	45.5
24	Labor Law	1.50	.931	47
18	Construction Cost Accounting	1.48	1.119	48
20	Principles of Accounting	1.46	.858	49
52	Hydraulics, Water, Sewerage	1.44	.929	50.5
58	Engineering Economics	1.44	.875	50.5
69	Psychology	1.41	.926	52
22	Insurance & Bonding	1.40	1.040	53

TABLE X (Continued)

Number	Elements	Means	Std. Dev.	Rank
7	Contractor Organization & Operation	1.38	1.053	54
16	Electrical; Estimating & Coordination	1.35	.969	55
34	Geology	1.33	1.031	56.5
15	Electrical; HVAC Theory & Design	1.33	.935	56.5
19	Principles of Economics	1.32	.894	58
39	Computer Programming	1.25	.860	59
68	Social Science, History & Government	1.19	.877	60
21	Finance	1.17	.907	61
38	Statistics: Business	1.13	.792	62.5
60	Highway Engineering	1.13	.832	62.5
40	Computer Data Processing	1.08	.848	64
62	Humanities: Literature & Fine Arts	1.03	.694	65
45	Differential Equations	1.00	.933	66
33	Chemistry	.91	.836	67
63	Philosophy	.83	.773	68
59	Advanced Structural Design	.71	.811	69.5
17	Systems Analysis & Operations Research	.71	.771	69.5
29	Real Estate Fundamentals	.68	.667	71

TABLE XI

DISTRIBUTION OF ELEMENTS BY LEVEL OF IMPORTANCE

Level of Importance	Numeric Scale	Frequency	Percent of Total Elements
Essential	3	3	4
Substantial Importance	2	44	62
Moderate Importance	1	24	34
No Importance	0	0	0
Totals		71	100

Elements ranking from 1 to 19, with a mean of 2.00 or greater, form a combination of basic technical construction skills, basic mathematics, engineering, and basic communication skills. This group of elements is strongly oriented toward field production operations. Conversely, elements relating to overall company management ranked below 20 and a mean of less than 2.00. Examples of elements in this group include:

> Construction Contract Law (1.87), Contractor Organization (1.38), Finance (1.17), Business Statistics (1.13), Labor Law, (1.50).

The response to perceptions of importance for mathematics elements placed the elements in the standard instructional sequence:

41.	Algebra	(2.32)
42.	Trigonometry	(2.32)
43.	Analytic Geometry	(1.92)

44. Calculus (1.52)
45. Differential Equations (1.00)

In contrast, respondents considered Element 49, Fundamentals of Structural Design, more important than the requisites to the course. Element 46, Statics and Mechanics, and Element 44, Calculus, are typical prerequisites to Structural Design and both ranked substantially lower in the overall list of elements.

Influence of Academic Background

For many years baccalaureate engineering programs have been a major source of personnel for construction project management. The engineering discipline evolved over the past half century into a rigid academic discipline with strong emphasis on mathematics and sciences, a lessor emphasis on socio-humanistic elements, and a very heavy emphasis in engineering theory and design concepts.

Within the past decade, baccalaureate programs in construction have become an additional source of personnel for construction project management. In contrast to engineering education, the construction curriculum is an approximate balance between science and mathematics, socio-humanistic elements, and basic engineering fundamentals. A heavy emphasis is placed on construction technologies and management.

Graduates of both the engineering and construction disciplines are included in this study, along with degree backgrounds in architecture and business. One respondent has a degree in science and another a degree in the humanities. Respondents with degrees in architecture (5) were included with the engineering group, as was the one degree in science. Respondents with business degrees (6) were included with the construction group, along with the degreed person in humanities. Hence, two groups were formed: a strong construction and management oriented group, and a strong engineering oriented group.

To determine and evaluate differences in perceptions of constructors by virtue of academic background toward the level of importance of the construction curriculum elements, responses from both engineering educated and construction educated groups were solicited. A T-Test of Significance was computed for each element, with the .05 level of significance used as a parameter to test the null hypothesis stated in Chapter II. The critical value for rejecting the null was 1.671 with 61 degrees of freedom.

Elements for which significant differences exist between the means of the two academic groups are included in Table XII. The data for all elements are reported in Appendix H. The null hypothesis was rejected for 22 of the 71 elements of the construction curricular guide.

TABLE XII

T-TEST OF SIGNIFICANCE FOR PERCEPTIONS OF ENGINEERING EDUCATED AND CONSTRUCTION EDUCATED RESPONDENTS TOWARD CONSTRUCTION EDUCATION ELEMENTS

SUMMARY OF ELEMENTS EXCEEDING CRITICAL VALUE OF T-STATISTIC

Number	Elements	T-Value 61 df	2 Tail Prob
7	Contractor Organization and Operation	-1.79	.078
11	Construction Safety	-2.06	.043
12	Project Scheduling	-2.16	.035
22	Insurance and Bonding	-3.36	.001
23	Personnel Management	-2.03	.047
24	Labor Law	-2.26	.010
25	Labor Relations	-2.11	.039
28	Fundamentals of Organization and Management	-2.16	.035
32	Engineering Physics	2.88	.006
33	Chemistry	2.05	.045
34	Geology	4.92	.000
37	Descriptive Geometry	1.93	.058
44	Calculus	2.06	.044
44	Differential Equations	1.95	.055
47	Mechanics of Materials	2.07	.042
51	Soil Mechanics	2.73	.008
52	Hydraulics, Water, Sewage	2.57	.012
53	Foundation Engineering	3.66	.001
56	Engineering Surveying	3.86	.000
57	Earthwork Surveying	2.31	.024

TABLE XII (Continued)

Number	Elements	T-Value 61 df	2 Tail Prob
58	Engineering Economics	2.09	.041
70	Undirected Elective Courses	-1.71	.092

$H_o = 1.671$ Significance Level 0.05 61 df

For those elements included in Table XII with a negative T-Statistic, the construction educated respondent indicated a higher level of importance when the mean of each group is compared for each element.

In a similar manner, the engineering educated person indicated a higher level of importance for elements with a positive T-Statistic when the mean of each group is compared for each element.

The first 8 elements in Table XII are concerned with construction organization, operations and management. The remainder of the elements included in Table XII, with the exception of Element 70, are engineering and science elements.

The academic background of the respondent appears to have significant influence on perceptions of the importance of elements of the construction curricula guide.

Experience as a Controlling Factor

The relationship between academic background and perceptions of curricular element importance when contrasted with the length of construction experience was investigated with the use of contingency table analysis and summarized by chi-square test of significance.

The experience of respondents ranged from 1 to 30 years of construction experience since graduation, with a mean of approximately 10 years. Graduates of construction programs had fewer than 14 years of experience, with a mean of approximately 5 years, and in contrast, engineering graduates a mean of over 15 years. The intent was to determine if experience was a factor which influenced perceptions of the level of importance of the construction elements.

Elements for which the null hypothesis was rejected are included in Table XIII. Critical values of chi-square and probability are reported in Appendix I for each element. Significant differences were found for 13 percent of the elements. The null hypothesis was rejected on 4 elements for the 1 to 8 years experience group and the null hypothesis was rejected for 5 of the elements for the 9 to 30 years of experience group. While it is apparent that experience is a significant factor for some elements, there is no indication of a systematic relationship existing between perceptions of element importance, academic background and length of construction for 87 percent of the elements.

Alternate Sources of Element Instruction

There are several possible alternatives to instruction for the educational elements of the AGC guidelines. The first is to include the element in an undergraduate program. This is the AGC recommendation for the elements listed in the guidelines. However, some elements may be appropriate for other forms of instruction: work experience; specialized short courses, non-degree courses and seminars; or graduate level courses leading to an advanced degree. The respondents were given the opportunity to indicate their choice

TABLE XIII

CHI-SQUARE TEST OF SIGNIFICANCE FOR ACADEMIC EDUCATION AND LEVEL OF CURRICULAR ELEMENT IMPORTANCE
CONTROL VARIABLE: LENGTH OF CONSTRUCTION EXPERIENCE SUMMARY OF ELEMENTS EXCEEDING THE CRITICAL VALUE OF CHI SQUARE

		1-8 Years			9-30 Years		
Number	Element	Engr N=9 Mean	Const N=27 Mean	Chi Square	Engr N=18 Mean	Const N=9 Mean	Chi Square
11	Construction Safety	1.111	2.000	11.822	1.555	1.888	4.548
22	Insurance and Bonding	1.000	1.852	4.606	.888	1.888	8.214
34	Geology	2.111	.777	15.888	1.888	1.111	4.837
39	Computer Programming	1.444	1.074	2.977	1.222	1.666	7.846
41	Algebra	2.222	2.185	.385	2.555	2.333	9.400
42	Trigonometry	2.333	2.185	1.548	2.611	2.111	11.892
56	Engineering Surveying	2.555	1.740	6.013	2.555	1.666	8.346
58	Engineering Economics	1.777	1.185	7.931	1.666	1.444	2.163
60	Highway Engineering	1.555	.963	9.407	1.166	1.111	1.154

$H_{o2} = 7.82$ Significance Level 0.05 with 3 degrees of freedom.

of an alternative source of instruction for each element, if the decision was made that the element was important for employment in construction but not appropriate for an undergraduate degree program.

Work Experience

Prior to the development of baccalaureate level construction education programs, the college graduate entering construction above the trades level learned the business of construction "on-the-job." Even now, students in construction programs are strongly urged to obtain work experience in construction before graduating to improve the transition from theory to the practical.

With awareness of the strong attitude of industry concerning work experience, the intent of the research was to investigate perceptions of experienced constructors toward elements of an undergraduate construction curricula as they relate to instruction through work experience.

Elements indicated by respondents as appropriate for instruction through work experience are included in Table XIV. With two exceptions, all elements included in the table are directly related to construction project operations and organization and management of the construction company. The two exceptions are Element 17, Systems Analysis and Operations Research, and Element 29,

TABLE XIV

WORK EXPERIENCE AS AN ALTERNATE SOURCE OF INSTRUCTION RANKED BY FREQUENCY OF RESPONSE

Number	Element	Total Frequency	Frequency		% of Total*
			Engr.	Const.	
7	Contractor Organization and Operation	19	12	7	30.16
8	Project Organization and Operation	19	11	8	30.16
6	Bidding Procedures	15	9	6	23.80
16	Electrical, Mechanical, Plumbing Systems: Estimating, Coordination	13	8	5	20.63
10	Construction Equipment	11	8	3	17.46
11	Construction Safety	10	8	2	15.87
14	Cost Control and Analysis	10	8	2	15.87
18	Construction Cost Accounting	10	6	4	15.87
3	Construction Contracts	9	6	3	14.28
2	Insurance and Bonding	8	3	0	12.69
1	Orientation Into Construction	7	3	4	11.11
12	Project Scheduling and Control	7	4	3	11.11
9	Building Materials	6	3	3	9.50
15	Electrical, Mechanical, Plumbing Theory and Design	6	5	1	9.50
17	Systems Analysis and Operations Research	6	2	4	9.50
25	Labor Relations	6	4	2	9.50
4	Cost Estimating	5	4	1	7.93
57	Earthwork Surveying	5	4	1	7.93

TABLE XIV (Continued)

Number	Element	Total Frequency	Frequency Engr.	Frequency Const.	% of Total
13	Construction Economics	4	2	3	6.35
30	Building Codes	4	2	2	6.35
55	Construction Surveying	4	2	2	6.35
67	Professional Ethics	4	2	2	6.35
2	Specifications and Drawings	3	3	0	4.76
5	Quantity Takeoff	3	2	1	4.76
23	Personnel Management	3	3	0	4.76
27	Construction Contract Law	3	0	3	4.76
29	Fundamentals of Real Estate	3	2	1	4.76
51	Soil Mechanics	3	1	2	4.76
56	Engineering Surveying	3	2	1	4.76
60	Highway Engineering	3	2	1	4.76
24	Labor Law	2	2	2	3.17
28	Fundamentals of Organization and Management	2	2	0	3.17
52	Hydraulics, Water, Sewage	2	2	0	3.17
58	Engineering Economics	2	2	0	3.17
66	Technical Report Writing	2	2	0	3.17
	Total Response	222	145	77	

*Percentage of total respondents.

Fundamentals of Real Estate, neither of which are typically obtained through work experience.

The engineering educated respondent strongly influenced the frequency of response on the 33 elements listed in the table. With a total response of 222 for the 33 elements, 65.3 percent were made by engineering educated persons. No elements listed with a frequency greater than 7 has a mean above 2.00 for level of importance, with most of the elements ranked at the moderate level of importance (mean approximately less than 1.50).

Non-Degree Special Courses

Available to construction personnel, particularly in metropolitan areas, are seminars and short courses on construction procedures and management techniques. These courses are generally non-credit and industry-sponsored. In addition, colleges and universities typically have special student classifications under which regular college classes are available to non-degree seeking persons.

The intent of this investigation was to determine if the above sources of instruction offer a viable alternative for instructional elements which are not as important to an undergraduate program, but still important for success of an individual in construction. Listed in Table XV are 33 elements recommended by respondents as appropriate for seminars, short courses, or non-degree credit

TABLE XV

NON-DEGREE SPECIAL COURSES RANKED BY FREQUENCY OF RESPONSE

Number	Element	Frequency*	% of Total
29	Fundamentals of Real Estate	15	23.8
28	Fundamentals of Organization and Management	9	14.28
33	Chemistry	8	12.69
40	Computer Data Processing	8	12.69
25	Labor Relations	7	11.11
17	Systems Analysis and Operations Research	6	9.52
22	Insurance and Bonding	6	9.52
23	Personnel Management	6	9.52
24	Labor Law	6	9.52
27	Construction Contract Law	6	9.52
34	Geology	6	9.52
15	Electrical, Mechanical, Plumbing Theory and Design	5	7.93
26	Business Law	5	7.93
39	Computer Programming	5	7.93
59	Advanced Structural Design	5	7.93
60	Highway Engineering	5	7.93
18	Construction Cost Accounting	4	6.43
21	Finance	4	6.34
38	Statistics: Business	4	6.34
62	Humanities: Literature and Fine Arts	4	6.34
64	Logic	4	6.34
11	Construction Safety	3	4.76

TABLE XV (Continued)

Number	Element	Frequency*	% of Total
16	Electrical, Mechanical, Plumbing Systems: Estimating, Coordination	3	4.76
19	Principles of Economics	3	4.76
20	Principles of Accounting	3	4.76
30	Building Codes	3	4.76
32	Engineering Physics	3	4.76
45	Differential Equations	3	4.76
52	Hydraulics, Water, Sewage	3	4.76
63	Philosophy	3	4.76
68	Social Science: History and Government	3	4.76
69	Psychology	3	4.76
71	Directed Electives	3	4.76

*Frequency less than 3 reported in Appendix .

courses. Twenty-four elements which had a response of two or less are not included in the table, but are included in the total data in Appendix G, Frequency of Response for Alternate Sources of Element Instruction.

The real estate element which ranked lowest in level of importance by respondents, received the highest number of responses in this category. Approximately 24 percent of the respondents indicated real estate should be obtained from special courses and not from an undergraduate construction program.

Fourteen percent of the respondents recommended instruction in Element 28, Fundamentals of Organization and Management, be obtained through non-degree courses. This element ranked in the upper 50 percent of elements in level of importance. Of the remaining elements in the table, 40 percent were ranked in the lower half of the rank order of elements. Fifteen of the 33 elements listed, or 24 percent of the total list of elements, could be obtained from a typical college of business offering of courses.

Graduate Level Courses

The original guidelines developed by the AGC education committee did not include recommendations for course work beyond the baccalaureate degree. Construction personnel seeking graduate courses looked to engineering or business administration. Only in the past five to seven years have construction graduate programs become available and then only on a limited scale. Twenty-four percent of the study participants had taken graduate courses, with eight percent of respondents having received a masters degree in business.

The intent of this segment of the study was to determine which elements, if any, respondents perceived as appropriate to graduate level work as opposed to undergraduate course work. Included in Table XVI are elements with a frequency greater than two, with the total response to this category reported in Appendix G, "Frequency of Response for Alternative Sources of Element Instruction."

TABLE XVI

GRADUATE LEVEL COURSES BY FREQUENCY OF RESPONSE

Number	Elements	Frequency*	Percent of Total
59	Advanced Structural Design	16	25.4
17	Systems Analysis and Operations Research	14	22.2
21	Finance	5	7.9
58	Engineering Economics	5	7.9
27	Construction Contract Law	4	6.3
3	Construction Contracts	3	4.7
24	Labor Law	3	4.7

*Frequency of less than 3 reported in Appendix G.

Out of 71 elements, respondents recommended only two elements with a relatively high frequency. Element 59, "Advanced Structural Design" was recommended by 25 percent of the respondents, and 22 percent of the respondents recommended Element 17, "Systems Analysis and Operations Research." Each element is typically available at the graduate level assuming prerequisite baccalaureate degrees, in this case -- engineering and business. The frequency of the remaining elements in the table is relatively low; however, all elements listed are appropriate to the graduate level. Forty-three percent of total elements had a frequency of one or two, indicating some interest on the part of respondents but considered insignificant response by the investigator.

Recommended New Elements

The original construction curricular guidelines distributed by the AGC education committee in 1967 have not been modified, hence the request for respondents to recommend new elements pertinent to present-day construction needs. New element recommendations are reported in Table XVII in the wording used by the respondent. Also included in the data are the educational degree background of the respondent recommending the element. While 29 different elements are listed, only three elements were recommended by more than one respondent. Three respondents recommended letter writing and

TABLE XVII

RECOMMENDED NEW ELEMENTS FOR UNDERGRADUATE CONSTRUCTION PROGRAMS

New Elements	Academic* Background	Frequency
SECTION I: Construction and Management Elements		
Industrial Construction .	C	1
Mining Construction	C	1
Plans and Specs: Mechanical and Electrical	C	1
Building Layout: Detailed	C	1
Lump Sum or Parameter Estimating	C	1
Construction Contract Negotiations	C	1
Field Experience (Co-op Program)	C	1
Field Systems Co-ordination	C	1
Public Relations	E	1
Internship in Selected Field	C	1
Construction Management Procedures (Assumed to be the contract system known as "CM")	C	1
Conceptual Estimating	C	1
Heavy and Highway Construction and Equipment	C	1
Heavy and Highway Take-off and Estimating	C	1
SECTION II: Basic Sciences and Engineering		
Basic Fundamentals of Water, Sewage Treatment	E	1
Ground Water	E	1
Fundamentals of Concrete	E	2
Graphics Perception and Analysis	C	1
Environmental Impact vs Construction	E	1

TABLE XVII (Continued)

New Elements	Academic* Background	Frequency
Production	C	1
Types of Forming Systems	C	1
Cost Evaluation	E	1
Photography	C	1
Basic Shop Courses	C	1
SECTION III: Socio-Humanistic Studies		
Human Relation: Motivational Techniques	C	2
Written Communications	C	1
Letter Writing	C	3
History of Engineering Works and Trends	E	1
Urban Growth Theory	C	1
Total		30

*Letter designation (C) indicates construction-educated respondent.

Letter designation (E) indicates engineering-educated respondent.

fundamentals of concrete and human relations were recommended by two respondents.

Three of the recommended elements are concerned with specialized areas of construction: industrial construction, mining, and heavy-highway construction. The contract system known as "construction management" which is an innovation of very recent years, was recommended by only one of the 63 respondents as a new element. Construction educated respondents recommended 76 percent of the elements listed.

Elements Not Needed

While given the opportunity to eliminate elements from the construction curricular guidelines as totally unimportant to a construction curriculum, respondents indicated little interest in doing so.

Elements with a frequency of response greater than two are included in Table XVIII. The total data are reported in Appendix G. Response to this category was minimal, with only an approximate 8 percent of respondents indicating any one element was not needed in an undergraduate program. All elements listed in Table XVIII are ranked in the lower half of the rank order list of elements. Construction educated respondents made 82 percent of responses, indicating a slightly stronger negative perception of the importance of the listed elements than the engineering educated respondents.

TABLE XVIII

SUMMARY OF RESPONSES FOR ELEMENTS "NOT NEEDED"*

Number	Element	Construction	Engineer	Total	% of Total
29	Real Estate	4	1	5	7.93
33	Chemistry	4	1	5	7.93
38	Statistics: Business	4	1	5	7.93
40	Computer Data Processing	5	0	5	7.93
44	Calculus	5	0	5	7.93
45	Differential Equations	4	1	5	7.93
63	Philosophy	4	1	5	7.93
31	General Physics	2	2	4	6.34
39	Computer Programming	3	1	4	6.34
59	Advanced Structural Design	3	1	4	6.34
19	Principles of Economics	3	0	3	4.76
21	Finance	3	0	3	4.76
34	Geology	2	1	3	4.76
37	Descriptive Geometry	2	1	3	4.76
46	Statics and Mechanics	3	0	3	4.76
64	Logic	3	0	3	4.76
65	Social Science: History, Government	2	1	3	4.76

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*Frequency less than 3 reported in Appendix .

Twelve of the 17 elements listed on the table are also listed in Table XV, Non-Degree Special Courses.

Summary of Alternate Sources of Instruction

A summary of responses to all categories of alternate sources of element instruction including the category of "Elements Not Need" are reported in Table XIX. Elements reported are those which respondents determined were either not needed in an undergraduate program or should be obtained from some other source than an undergraduate program. Those elements with responses less than 25 percent of the total possible are included in Appendix G, Frequency of Response for Alternate Sources of Element Instruction.

Summary

The purpose of this chapter was to present the analysis of data related to perceptions of experienced constructors toward elements of an undergraduate construction curricular guide.

To investigate perceptions of constructors, the means and standard deviation of responses were computed and rank ordered. Approximately four percent of the elements were perceived by respondents to be "essential," sixty-seven percent of the elements were included in the "substantially important" level; thirty-four percent of the elements were in the "moderately important" level. No elements were included at the "no" importance level.

TABLE XIX

SUMMARY OF RESPONSES BY PERCENTAGES TO ALTERNATE SOURCES OF ELEMENT INSTRUCTION AND ELEMENTS NOT NEEDED

Number	Element	Frequency	% of Total*
17	Systems Analysis and Operations Research	27	43
59	Advanced Structural Design	25	40
8	Project Organization and Operations	20	32
7	Contractor Organization and Operations	19	30
29	Fundamentals of Real Estate	18	29
22	Insurance and Bonding	17	27
18	Construction Cost Accounting	17	27
16	Electrical, Mechanical, Plumbing Systems: Estimating, Coordination	17	27

*Percent of total respondents.

Hypothesis Ho_1 concerning differences in academic background and perceptions of element importance was tested using T-tests of significance. The null hypothesis was rejected on 22 of 71 elements. The 0.05 level of significance was used as a parameter to test the null hypothesis.

Hypothesis Ho_2 concerning academic background and perceptions of element importance when controlled for experience was tested using Chi-Square test of Significance. The null hypothesis was rejected on 9 of 71 elements of the curricular elements. The 0.05 level of significance was used as a parameter to test the null hypothesis.

Three alternate sources of element instruction were investigated. The majority of elements recommended for work experience as an alternative source of instruction were related to construction management. Over 65 percent of the responses were made by engineering educated respondents.

Thirty-three elements were recommended for seminars or short courses as a method of element instruction. The frequency of response ranged from 24 percent of total respondents to less than four percent of respondents.

Graduate level courses were recommended for only two elements at a relatively high level of response, with an approximate 22 to 25 percent of total responses. The frequency for other elements was less than [illegible] with an average of approximately two responses.

Respondents were asked to recommend new curricular elements. Twenty-nine different elements were listed; however, only one element had a frequency of 3, and two other elements had a frequency of 2.

The maximum response to any one element in the category of "Elements Not Needed" was 5, which occurred on seven elements. Twenty-four percent of the elements had a response of 3 or greater, with construction educated respondents making 82 percent of those responses.

A summary of responses to alternate sources of instruction and elements not needed indicated eight elements with greater than 25 percent of respondents recommending the elements not be included in an undergraduate construction curriculum.

CHAPTER IV

SIGNIFICANCE OF CONSTRUCTION CURRICULAR ELEMENTS

Introduction

The education committee of the Associated General Contractors of America developed baccalaureate level construction curricular guidelines which were distributed in 1967. While some construction programs were granting degrees in construction as early as 1935, the major growth of construction education at the baccalaureate level did not occur until the mid-1960's. The AGC construction education guideline(s) has been the only nationally distributed recommendations for content of a construction curriculum. After nearly a decade of use by academic-industry advisory committees and construction faculty in the development of construction programs, the question persists as to the significance and desirability of elements contained in the guidelines. The purpose of this study was to investigate the perceptions of experienced constructors toward the importance of the AGC construction curricular elements.

The study involved three basic areas of concern:

(a) Perceptions of element importance as perceived by experienced constructors.

(b) Relationship of academic background and length of construction experience to perceptions of importance of construction curricular elements.

(c) Sources of element instruction other than an undergraduate construction curriculum.

Study Population

The sample population consisted of employees of construction firms that are members of the two AGC chapters in Colorado. Sixty-three constructors of the 125 originally selected responded to the study questionnaire. Respondents were employed primarily by general contractors doing commercial and heavy-highway construction. The majority of respondents had responsibilities in project management and estimating. The mean years of construction experience was 10, with a range of 1 to 30 years. Construction education respondents had fewer than 14 years of experience, with a mean of 5 years. Engineering educated constructors had a mean of 15 years of construction experience. The two primary educational backgrounds of respondents were in construction and engineering, with other degrees in architecture and business.

Respondents with construction education degrees totaled 27, respondents with engineering degrees totaled 23, and respondents with other degrees totaled 13. Five of the respondents had received a master's degree in business and six of the respondents were registered as engineers or architects.

It is the opinion of the investigator that the respondents represent a cross section of construction company personnel below the executive level and with primary functions in field and project management.

Summary of Findings

Constructor perceptions of importance of the curricular elements were summarized by the mean and standard deviation for each element and then the elements rank ordered. Elements were classified into the four levels of element importance by equating: No Importance to 0; Moderate Importance to 1; Substantial Importance to 2; and Essential to 3. Forty-four percent of the elements were classified of substantial importance, and thirty-four percent of the elements were classified of moderate importance. Significantly, only three elements could be included in the essential level and these were concerned with oral communications, surveying, and drawings and specifications. No construction project will ever be completed without these three elements. In contrast, no elements were classified at the lowest level of no importance.

Project and field construction-oriented elements--that is, elements directed toward activities and the understandings of field construction operations--were ranked in the upper 30 percent of the total element list. A second general grouping concerning overall company management and upper level decision making were ranked in the middle third of the element list. A third general grouping relating to advanced subject areas involving theory and greater abstract thinking were grouped in the lower third. The ranking of mathematical elements was in the normal sequence of instruction, beginning with algebra, then to trig, analytical geometry, calculus, and finally, differential equations. However, elements related to engineering structures did not occur in a logical educational sequence. The prerequisites to basic structural design of statistics, mechanics, and calculus were all ranked lower in importance than the structural design courses in steel, concrete, and wood. Advanced structures elements were ranked substantially lower than any other engineering element.

The null hypothesis tested to determine differences in perceptions between engineering educated and construction educated constructors toward the curricular elements was tested by T-test of significance. A significant difference was found on 35 percent of the elements. Nine of these elements were in the construction management area and 12 in the engineering, math, and science area.

Further analysis of the influence of academic background indicates that:

(a) For elements from 1 to 30, relating to construction management, construction educated respondents indicated a higher level of importance than did engineering educated respondents on 83 percent of the elements within this group.

(b) For elements from 31 to 61, relating to math, science, and engineering, engineering respondents indicated a higher level of importance than did construction educated respondents on 93 percent of elements within this group.

(c) For elements from 61 to 71, relating to socio-humanistic studies, engineering educated respondents indicated a higher level of importance than did construction educated respondents on 64 percent of elements within this group.

The null hypothesis tested to determine if a systematic relationship existed between academic background and perceptions of element importance when related to length of construction experience was tested by chi-square test of significance. A significant systematic relationship was found to exist in only 9 of the 71 elements. There was no indication of a systematic relationship between academic background and perceptions of element importance when related to length of experience on 67 percent of the elements.

Alternate Sources of Instruction

The highest frequency of response to the three alternate sources of instruction was in the work experience category. Elements with the greatest frequency were primarily related to construction project management. Thirty percent of the respondents indicated two elements: contractor organization and project organization and operation, should be obtained through work experience. Twenty-four percent of the respondents indicated bidding procedures should also be obtained by on-the-job experience. It is difficult, if not almost impossible, to duplicate the process of bidding a project in a classroom environment. Engineering educated respondents made up 65 percent of the responses in this category.

In the category of non-degree special courses, only one element had a substantial response, with 24 percent of the respondents indicating real estate should be obtained from non-degree courses. Approximately 50 percent of the elements checked in this category are concerned with business and management, e.g., law, economics, finance, and personnel management. Many of these elements are readily available from junior college programs and industry seminars.

The use of graduate courses as an alternate source of instruction was substantial for only two elements. Twenty-five percent of the respondents checked advanced structural design as appropriate for graduate level courses, and twenty-two percent of the respondents indicated systems analysis and operations should be taken as a graduate course. The frequency of response to all other elements for this category were very low, with finance and engineering economics receiving five responses each and construction contract law receiving four responses. A frequency of fewer than three was recorded for 43 percent of the elements.

To determine if new elements were desirable, respondents were requested to write in their recommendations for elements which would seem pertinent to present-day construction operations and appropriate to undergraduate construction curricula. Twenty-nine different elements were recommended. Letter writing was suggested by three respondents, which was the highest frequency of any new element recommendation. Construction educated respondents made 76 percent of the recommendations for new elements.

Respondents were given the opportunity to check elements which were perceived to be not needed in an undergraduate program. Eight percent of the respondents indicated that real estate, chemistry, data processing, calculus, differential equations and philosophy elements were not needed in undergraduate programs. A frequency of fewer than five was recorded for 47 percent of the elements.

A summary of all responses to the categories of work experience, non-degree special courses, graduate level courses and elements not needed, for each element is a reflection of how important respondents perceived the element to be for undergraduate construction curricula. Eight of the 71 elements were found to have a range of 27 to 43 percent of the respondents indicating these elements should be obtained from a source of instruction other than an undergraduate program. The elements are:

7. Contractor Organization and Operations (30%)
8. Project Organization and Operations (32%)
16. Electrical, Mechanical, Plumbing Systems: Estimating and Coordination (27%)
17. Systems Analysis and Operations Research (43%)
18. Construction Cost Accounting (27%)
22. Insurance and Bonding (27%)
29. Fundamentals of Real Estate (29%)
59. Advanced Structural Design (40%)

No element received sufficient negative response to exclude the element from the guidelines.

Conclusions

On the basis of the findings of this study, the following conclusions are drawn in relation to the problem posed for the investigation:

1. The elements ranking highest are those directly related to the responsibility of the respondent. Conversely, elements relating to upper levels of management are ranked lower in the list of elements. The apparent conclusion may be drawn that respondents found it difficult to look beyond their own particular job

responsibilities in the construction process to determine the value of construction education elements which benefit the total construction industry.

2. The academic background of the respondent has a significant influence on his perceptions of the importance of elements for a construction education undergraduate curriculum. Respondents related strongly to their own academic background in perceiving the importance of the elements and apparently <u>not</u> to the various functions of the total construction process.

3. The length of construction experience does not appear to have a significant influence on the perceptions of constructors toward the level of importance of the construction curricular elements.

4. Work experience still retains a strong influence as an integral part of construction employment. The engineering educated respondent did not appear to strongly support the concept of construction education elements for an undergraduate construction curriculum, instead recommending work experience as an alternative. The conclusion may be drawn that classroom instruction for many aspects of construction technology and management has only partially been accepted by industry personnel.

5. Special courses and graduate programs, while strongly recommended for a very few elements, did not appear to offer a viable alternative for the majority of elements. In a similar manner,

suggestions for new elements was minimal, suggesting the existing original AGC construction curricular element list was reasonably complete. However, from the total response to the alternative sources of instruction and elements not needed, the conclusion may be drawn that the following elements are substantially less important than all other undergraduate elements of the AGC construction education guidelines. Listed by element number, they are:

7. Contractor Organization and Operations
8. Project Organization and Operations
16. Electrical, Mechanical, Plumbing Systems: Estimating, Coordination
17. Systems Analysis and Operations Research
18. Construction Cost Accounting
22. Insurance and Bonding
29. Fundamentals of Real Estate
59. Advanced Structural Design

6. From the relative level of importance indicated for the elements and absence of response to the alternative sources of element instruction, with the exception of elements listed above, the conclusion is drawn that the original element list is as important and valid today as it was when developed in the early 1960's.

Inference

The following statement may not be completely supported by the analysis of data but seems pertinent to the scope of this study. Thus, the following inference is made:

The educational background of the respondent appeared to play a larger part in his perceptions of importance than did his experience or his understanding of the educational requirements of positions h higher than his own responsibilities. That is, what the respondent took in his undergraduate program seemed more important than the actual educational background desirable to fulfill his immediate and long-range responsibilities.

Engineering respondents indicated a relatively high level of importance to engineering subjects used but very little in the process of managing a construction project, yet downgraded insurance and bonding, which a construction company deals with on a week-to-week basis. Respondents downgraded elements concerned with the electrical and mechanical systems of the building, and yet, one of the more numerous complaints of contractor employers was that field personnel could not interpret or effectively understand the coordination of mechanical and electrical systems during construction.

Recommendations for Implementation and Further Study

Based on the findings and conclusions of this study, the following recommendations are offered:

1. Based on the apparent influence of academic background on perceptions of constructors toward elements of a construction curriculum, it is recommended that members of a curriculum advisory be comprised of members of differing educational backgrounds to give balance to their input into the deliberations of the construction advisory committee.

2. Based on the perceptions indicated by respondents toward elements related to the construction management aspects of overall construction company operations, which were ranked low in importance or recommended for exclusion from the list of elements, and because many construction programs contain these elements, it is recommended that the study be replicated with a population drawn from the executive and upper level management persons to determine if the perceptions of project personnel and company management are comparable.

3. Respondents to this study placed an emphasis on elements related to construction which could be obtained through work experience. The role and place of required construction internships and co-op programs prior to graduation should be studied.

4. The study should be replicated with comparable population, except in different sections of the country through AGC chapters to determine differences in perceptions by virtue of geographic location and custom of operations. Assuming the above study, a

similar investigation should be attempted through the Associated Building Contractor Association, a sister construction industry organization with a different operational philosophy but which includes the same general categories of contractors as the AGC.

5. The AGC member construction firm and its personnel are but a very small segment of the industry. The question needs to be asked: How different are the field and management personnel of the residential builder or the personnel that construct power plants or pipelines? Can the elements of this study be used with confidence in other segments of the construction industry or should an entirely new list of elements be developed for each segment of construction?

6. In light of the minority response to alternate sources of element instruction, the AGC education committee should consider additional guideline recommendations concerning the importance of work experience (co-op or internship) prior to graduation; the potential for specialized industry seminars (when available) as supplementary undergraduate instruction; and begin development of guidelines for construction education at the graduate level.

More Brick and Mortar: A Postscript

A purpose of this study was to gain a greater depth of understanding of constructors in the field in order to continue development and improvement of exist [illegible] new construction curricul assumption has been made by many educators, including the author, that a comprehensive coverage of construction operations and management was desirable and, in fact, a necessity to understand the complex process of construction.

This study disturbs that assumption and clearly indicates the necessity of further analysis of the educational needs of the construction industry. The context of this study should be placed in a proper perspective. Even if the population of this study were in fact a true sample, it was a sample of only one segment of a massive industry. The experience of the author has indicated that graduates of a program essentially patterned after the AGC education guidelines are employed in every possible segment of the industry, and if responsibility and monetary rewards are any indication of success, these graduates have succeeded. The question that could be asked is: Was it the educational program that helped them to succeed or was it the individual who would have succeeded regardless of his degree background?

Construction education is an unfinished building compared to the historic structures of the academic world. At present, many persons are teaching in construction programs, but few persons are attempting to further the knowledge needed to develop construction education with academic stature. To the degree this study has developed some further unde [illegible] perceptions of construction field and project personnel toward construction education, a little more brick and mortar have been added to the academic structure of construction education.

APPENDICES

APPENDIX A

LIST OF PARTICIPATING FIRMS

(Available from Author)

APPENDIX B

INTRODUCTORY LETTERS TO CONSTRUCTION COMPANY PRESIDENTS AND POTENTIAL SURVEY PARTICIPANTS

(Available from Author)

APPENDIX C

SURVEY INSTRUMENT

RESEARCH STUDY: AN ANALYSIS OF CONSTRUCTION CURRICULA ELEMENTS

PART I: PERSONAL BACKGROUND DATA

Instructions: Responses to this questionnaire will be placed on computer cards. Please read each item and place the number of the most appropriate response in the box on the right hand side of the form.

A. Present Employer (spell out) ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

B. Type of construction performed by your company Primary type: ☐☐

Secondary type: ☐☐

1. High rise residential
2. Commercial
3. Institutional
4. Heavy-Highway
5. Highway
6. Utility
7. Industrial
8. Commercial-Utility
9. Commercial-Industrial
10. (Other ______________________)

C. Title which best describes your current position Primary title: ☐☐

Secondary title: ☐☐

1. Field engineer
2. Assistant Superintendent
3. Project Engineer
4. Superintendent
5. Estimator
6. Scheduler
7. Cost Control
8. Project Manager
9. Office Manager
10. (Other ______________________)

D. Years of work experience in current position:
(If less than one year, indicate one) Years: ☐☐

E. Total years of construction work experience after graduation: Years: ☐☐

F. Indicate year of graduation from undergraduate degree program: Year: ☐☐☐☐

G. Indicate undergraduate degree program in which you received your degree: Degree: ☐☐

1. Architecture - 4 year
2. Architecture - 5 year
3. Business
4. Construction - Building
5. Construction - Engineering
6. Construction - Management
7. Engineering - Civil
8. Engineering - Electrical
9. Engineering - Mechanical
10. Science
11. Social Science
12. Humanities
13. (Other ______________________)

H. From what institution did you receive your degree:

(Abbreviate as necessary) ☐☐☐☐☐☐☐☐☐☐☐☐

I. Have you taken courses at the graduate level: Yes ☐ No ☐

J. If you have a graduate degree, indicate type: MBA ☐ MS ☐ MEd ☐ PhD ☐

K. Have you taken continuing education courses: Yes ☐ No ☐

L. Are you a registered: Architect ☐☐ Professional Engineer ☐☐
yes no yes no

INSTRUCTIONS: On the LEFT of the listed elements, indicate the level of importance that you attach to each element as it relates to inclusion in an undergraduate construction curricula. (Mark only one square before each element.)

If you do NOT feel the element is appropriate for an undergraduate curricula, indicate in the squares on the RIGHT where instruction in this element could or should be obtained. If the element is not needed at all, use the extreme right hand column.

Perception of Element Importance to Under-Graduate Program

Alternate Source of Element Instruction

No Importance	Moderate Importance	Substantial Importance	Essential		ELEMENTS	Work Experience	Non-degree Special Courses	Graduate Program	Not Needed
☐	☐	☐	☐			☐	☐	☐	☐
					PART II: CONSTRUCTION AND MANAGEMENT ELEMENTS				
☐	☐	☐	☐	1.	Orientation into construction	☐	☐	☐	☐
☐	☐	☐	☐	2.	Specifications and drawings	☐	☐	☐	☐
☐	☐	☐	☐	3.	Construction contracts	☐	☐	☐	☐
☐	☐	☐	☐	4.	Cost estimating	☐	☐	☐	☐
☐	☐	☐	☐	5.	Quantity takeoff	☐	☐	☐	☐
☐	☐	☐	☐	6.	Bidding procedures	☐	☐	☐	☐
☐	☐	☐	☐	7.	Contractor organization and operations	☐	☐	☐	☐
☐	☐	☐	☐	8.	Project organization and operations	☐	☐	☐	☐
☐	☐	☐	☐	9.	Building materials	☐	☐	☐	☐
☐	☐	☐	☐	10.	Construction equipment	☐	☐	☐	☐
☐	☐	☐	☐	11.	Construction safety	☐	☐	☐	☐
☐	☐	☐	☐	12.	Project scheduling and control	☐	☐	☐	☐
☐	☐	☐	☐	13.	Construction economics	☐	☐	☐	☐
☐	☐	☐	☐	14.	Cost control and analysis	☐	☐	☐	☐
☐	☐	☐	☐	15.	Electrical, mechanical, plumbing theory and design	☐	☐	☐	☐
☐	☐	☐	☐	16.	Electrical, mechanical, plumbing systems; estimating, coordination	☐	☐	☐	☐
☐	☐	☐	☐	17.	Systems analysis and operations research . .	☐	☐	☐	☐
☐	☐	☐	☐	18.	Construction cost accounting	☐	☐	☐	☐
☐	☐	☐	☐	19.	Principles of economics	☐	☐	☐	☐
☐	☐	☐	☐	20.	Principles of accounting	☐	☐	☐	☐
☐	☐	☐	☐	21.	Finance	☐	☐	☐	☐

☐ ☐ ☐ ☐ 22. Insurance and bonding (construction) ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 23. Personnel management ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 24. Labor law ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 25. Labor relations ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 26. Business law ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 27. Construction contract law ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 28. Fundamentals of organization and management ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 29. Fundamentals of real estate ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 30. Building codes ☐ ☐ ☐ ☐

List additional <u>ESSENTIAL</u> elements

☐ 31. ____________________ ☐ ☐ ☐
☐ 32. ____________________ ☐ ☐ ☐
☐ 33. ____________________ ☐ ☐ ☐
☐ 34. ____________________ ☐ ☐ ☐

PART III: BASIC SCIENCES AND ENGINEERING: BASIC AND APPLIED

☐ ☐ ☐ ☐ 1. General physics ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 2. Engineering physics ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 3. Chemistry ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 4. Geology ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 5. Graphics: Mechanical ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 6. Graphics: Architectural ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 7. Descriptive Geometry ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 8. Statistics: Business ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 9. Computer programming ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 10. Computer data processing ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 11. Algebra ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 12. Trigonometry ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 13. Analytic Geometry ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 14. Calculus ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 15. Differential Equations ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 16. Statistics and mechanics ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 17. Mechanics of materials ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 18. Properties of construction materials ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 19. Fundamentals of structural design ☐ ☐ ☐ ☐
☐ ☐ ☐ ☐ 20. Structural design: wood, concrete, steel ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 21. Soil mechanics . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 22. Hydraulics, water, sewage . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 23. Foundation engineering . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 24. Concrete form design . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 25. Construction surveying . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 26. Engineering surveying . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 27. Earthwork surveying . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 28. Engineering economics . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 29. Advanced structural design . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 30. Highway engineering . . . . ☐ ☐ ☐ ☐

List additional <u>ESSENTIAL</u> elements

☐ 31. ______________________________ ☐ ☐ ☐

☐ 32. ______________________________ ☐ ☐ ☐

☐ 33. ______________________________ ☐ ☐ ☐

☐ 34. ______________________________ ☐ ☐ ☐

PART IV: SOCIO-HUMANISTIC STUDIES

☐ ☐ ☐ ☐ 1. English composition . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 2. Humanities: literature and fine arts . . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 3. Philosophy . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 4. Logic . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 5. Oral communications . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 6. Technical report writing . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 7. Professional ethics . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 8. Social Science: history, government . . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 9. Psychology . . . . ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 10. Undirected elective courses (your own choice) ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ 11. Directed elective courses offering alternative or advanced courses in a major area . . . . . ☐ ☐ ☐ ☐

List additional <u>ESSENTIAL</u> elements

☐ 12. ______________________________ ☐ ☐ ☐

☐ 13. ______________________________ ☐ ☐ ☐

APPENDIX D

YEARS OF CONSTRUCTION WORK EXPERIENCE SINCE GRADUATION

APPENDIX D

YEARS OF CONSTRUCTION WORK EXPERIENCE SINCE GRADUATION

Years	Frequency	Percent	Years	Frequency	Percent
1	3	4.8	16	0	0
2	4	6.3	17	2	3.2
3	5	7.9	18	2	3.2
4	7	11.1	19	1	1.6
5	5	7.9	20	2	3.2
6	4	6.3	21	0	0
7	7	11.1	22	1	1.6
8	1	1.6	23	2	3.2
9	1	1.6	24	2	3.2
10	4	6.3	25	1	1.6
11	1	1.6	26	1	1.6
12	2	3.2	27	0	0
13	1	1.6	28	0	0
14	2	3.2	29	0	0
15	0	0	30	2	3.2

Mean 10.174 years Total 63

Std. Dev. 7.99 years

APPENDIX E

YEARS OF WORK EXPERIENCE IN CURRENT POSITION

APPENDIX E

YEARS OF WORK EXPERIENCE IN CURRENT POSITION

Years	Frequency	Percent
1	17	27
2	13	20.6
3	10	15.9
4	4	6.3
5	3	4.8
6	2	3.2
7	2	3.2
8	1	1.6
9	2	3.2
10	2	3.2
12-16	3	
20-30	4	
Total	63	

Mean 4.9365 years

Std. Dev. 5.95 years

APPENDIX F

RANK ORDER OF CONSTRUCTION CURRICULAR ELEMENTS

APPENDIX F

FREQUENCY DISTRIBUTION OF RESPONDENT'S PERCEPTIONS OF LEVEL OF IMPORTANCE BY ELEMENTS

		Level of Importance					
No.	Element	None	Moderate	Substantial	Essential	Mean	Std. Dev.
CONSTRUCTION & MANAGEMENT ELEMENTS							
1.	Orientation into Construction	8	10	22	23	1.952	1.022
2.	Specifications & Drawings	1	7	9	46	2.587	.754
3.	Construction contracts	7	8	20	28	2.095	1.011
4.	Cost estimating	2	9	24	28	2.238	.817
5.	Quantity takeoff	2	8	22	31	2.301	.815
6.	Bidding procedures	13	16	21	13	1.539	1.044
7.	Contractor organization & operations	15	21	15	12	1.380	1.053
8.	Project organization & operations	17	12	18	16	1.523	1.148
9.	Building materials	2	20	28	13	1.825	.793
10.	Construction equipment	8	23	20	12	1.571	.945

		Level of Importance					
No.	Element	None	Moderate	Substantial	Essential	Mean	Std. Dev.
11.	Construction safety	10	13	26	14	1.698	.994
12.	Project scheduling & control	4	6	22	31	2.269	.883
13.	Construction economics	5	15	19	24	1.984	.975
14.	Cost control & analysis	8	12	18	25	1.952	1.053
15.	Electrical, mechanical, plumbing theory & design	11	29	14	9	1.333	.933
16.	Electrical, mechanical, plumbing systems: estimating, coordination	13	24	17	9	1.349	.969
17.	Systems analysis & operations research	30	21	12	0	.714	.771
18.	Construction cost accounting	16	16	16	15	1.476	1.119
19.	Principles of economics	10	31	14	8	1.317	.894
20.	Principles of accounting	8	25	23	7	1.460	.858
21.	Finance	14	31	11	7	1.174	.907
22.	Insurance & bonding (construction)	15	19	18	11	1.396	1.040

		Level of Importance					
No.	Element	None	Moderate	Substantial	Essential	Mean	Std. Dev.
23.	Personnel management	10	14	21	18	1.746	1.046
24.	Labor law	10	21	23	9	1.492	.931
25.	Labor relations	13	14	23	13	1.571	1.042
26.	Business law	7	15	29	12	1.730	.901
27.	Construction contract law	11	6	26	20	1.873	1.054
28.	Fundamentals of organization & management	10	13	19	21	1.809	1.075
29.	Fundamentals of real estate	26	32	4	1	.682	.667
30.	Building codes	7	20	23	13	1.666	.933
BASIC SCIENCES & ENGINEERING: BASIC & APPLIED							
31.	General physics	10	20	21	12	1.555	.980
32.	Engineering physics	8	18	19	18	1.746	1.015
33.	Chemistry	21	31	7	4	.904	.836
34.	Geology	14	26	11	12	1.333	1.031
35.	Graphics: Mechanical	6	17	25	15	1.777	.923

		Level of Importance					
No.	Element	None	Moderate	Substantial	Essential	Mean	Std. Dev.
36.	Graphics: Architectural	5	10	26	22	2.031	.915
37.	Descriptive geometry	6	19	25	13	1.714	.905
38.	Statistics: Business	13	32	15	3	1.126	.792
39.	Computer programming	12	28	18	5	1.253	.860
40.	Computer data processing	16	30	13	4	1.079	.848
41.	Algebra	3	10	14	36	2.317	.912
42.	Trigonometry	3	8	18	34	2.317	.876
43.	Analytic geometry	5	16	21	21	1.920	.955
44.	Calculus	11	20	20	12	1.523	.997
45.	Differential equations	24	18	18	3	1.000	.933
46.	Statics & mechanics	7	11	20	25	2.000	1.016
47.	Mechanics of materials	2	10	20	31	2.269	.846
48.	Properties of construction materials	1	10	19	23	2.333	.803
49.	Fundamentals of structural design	6	24	33	0	2.428	.665

		Level of Importance					
No.	Element	None	Moderate	Substantial	Essential	Mean	Std. Dev.
50.	Structural design: Wood, concrete, steel	1	10	21	31	2.301	.795
51.	Soil mechanics	3	13	31	16	1.952	.811
52.	Hydraulics, water, sewage	11	21	23	8	1.444	.929
53.	Foundation engineering	3	16	27	17	1.920	.848
54.	Concrete form design	2	7	27	27	2.253	.788
55.	Construction surveying	1	2	14	46	2.666	.622
56.	Engineering surveying	4	13	20	26	2.079	.938
57.	Earthwork surveying	3	11	20	29	2.190	.895
58.	Engineering economics	8	27	20	8	1.444	.875
59.	Advanced structural design	30	23	8	2	.714	.811
60.	Highway engineering	14	31	14	4	1.126	.832
SOCIO-HUMANISTIC STUDIES							
61.	English composition	2	9	25	27	2.222	.812

No.	Element	Level of Importance None	 Moderate	 Substantial	 Essential	Mean	Std. Dev.
62.	Humanities: Literature & fine arts	12	39	10	2	1.031	.694
63.	Philosophy	24	27	11	1	.825	.777
64.	Logic	9	16	22	15	1.698	.994
65.	Oral communications	1	4	15	43	2.587	.687
66.	Technical report writing	4	13	21	25	2.063	.931
67.	Professional ethics	7	15	22	19	1.841	.987
68.	Social science: history, government	13	31	13	6	1.190	.877
69.	Psychology	11	23	21	8	1.412	.926
70.	Undirected elective courses	11	22	11	19	1.603	1.100
71.	Directed elective courses offering alternative or advanced courses in a major area	7	21	18	17	1.714	.990

APPENDIX G

FREQUENCY OF RESPONSE FOR ALTERNATE SOURCES OF INSTRUCTION

APPENDIX G

FREQUENCY OF RESPONSE FOR ALTERNATE SOURCES OF ELEMENT INSTRUCTION

Number	Elements	Work Experience	Non-Degree Special Course	Graduate Program	Not Needed	Row Totals
1	Orientation into Construction	7	2	0	1	10
2	Specifications and Drawings	3	0	0	0	3
3	Construction Contracts	9	0	3	0	12
4	Cost Estimating	5	1	0	0	6
5	Quantity Takeoff	3	1	0	0	4
6	Bidding Procedures	15	0	0	0	15
7	Contractor Organization and Operations	19	0	0	0	19
8	Project Organization and Operations	19	0	0	1	20
9	Building Materials	6	0	0	0	6
10	Construction Equipment	11	2	0	0	13
11	Construction Safety	10	3	0	0	13
12	Project Scheduling and Control	7	1	0	0	8
13	Construction Economics	4	1	1	0	6
14	Cost Control and Analysis	10	1	1	0	12
15	Electrical, Mechanical, Plumbing Theory and Design	6	5	0	0	11

Number	Elements	Work Experience	Non-Degree Special Course	Graduate Program	Not Needed	Row Totals
16	Electrical, Mechanical, Plumbing Systems: Estimating, Coordination	13	3	1	0	17
17	Systems Analysis and Operations Research	6	6	14	1	27
18	Construction Cost Accounting	10	4	2	1	17
19	Principles of Economics	0	3	2	3	8
20	Principles of Accounting	0	3	1	2	7
21	Finance	1	4	5	3	13
22	Insurance and Bonding (Construction)	8	6	2	1	17
23	Personnel Management	3	6	2	0	11
24	Labor Law	2	6	3	0	11
25	Labor Relations	6	7	1	0	14
26	Business Law	1	5	2	1	9
27	Construction Contract Law	3	6	4	0	13
28	Fundamentals of Organization and Management	2	9	0	0	11
29	Fundamentals of Real Estate	3	15	0	5	23
30	Building Codes	4	3	2	1	10
31	General Physics	0	1	1	4	6

Number	Elements	Work Experience	Non-Degree Special Course	Graduate Program	Not Needed	Row Total
32	Engineering Physics	0	3	1	1	5
33	Chemistry	0	8	0	5	13
34	Geology	0	6	0	3	9
35	Graphics: Mechanical	1	1	0	2	4
36	Graphics: Architectural	1	1	0	1	3
37	Descriptive Geometry	0	0	0	4	4
38	Statistics: Business	0	4	1	5	10
39	Computer Programming	0	5	1	4	10
40	Computer Data Processing	0	8	1	5	14
41	Algebra	0	2	0	0	2
42	Trigonometry	1	1	0	0	2
43	Analytic Geometry	0	0	1	2	3
44	Calculus	0	2	1	5	8
45	Differential Equations	0	3	1	5	9
46	Statistics and Mechanics	0	1	1	3	5
47	Mechanics of Materials	0	0	1	0	1
48	Properties of Construction Materials	1	0	2	0	3
49	Fundamentals of Structural Design	0	0	1	0	1

Number	Elements	Work Experience	Non-Degree Special Course	Graduate Program	Not Needed	Rov Total
50	Structural Design: Wood, Concrete, Steel	0	1	2	1	4
51	Soil Mechanics	3	0	1	0	4
52	Hydraulics, Water, Sewage	2	3	0	2	7
53	Foundation Engineering	0	1	0	0	1
54	Concrete Form Design	1	1	1	0	3
55	Construction Surveying	4	0	0	0	4
56	Engineering Surveying	3	1	0	2	6
57	Earthwork Surveying	5	0	0	1	6
58	Engineering Economics	2	1	5	2	10
59	Advanced Structural Design	0	5	16	4	25
60	Highway Engineering	3	5	4	2	14
61	English Composition	1	1	0	1	3
62	Humanities: Literature and Fine Arts	0	4	1	2	7
63	Philosophy	1	3	0	5	9
64	Logic	1	4	0	3	8
65	Oral Communications	1	0	0	0	1
66	Technical Report Writing	2	2	0	1	5

umber	Elements	Work Experience	Non-Degree Special Course	Graduate Program	Not Needed	Row Totals
67	Professional Ethics	4	2	0	1	7
68	Social Science: History, Government	0	3	0	3	6
69	Psychology	0	3	0	2	5
70	Undirected Elective Courses	1	2	1	0	4
71	Directed Elective Courses Offering Alternative or Advanced Courses in a Major Area	0	3	2	0	5
	Totals	227	194	92	101	

APPENDIX H

T-TEST OF SIGNIFICANCE FOR PERCEPTION OF ENGINEERING EDUCATED AND CONSTRUCTION EDUCATED RESPONDENTS TOWARD CONSTRUCTION EDUCATION ELEMENTS

APPENDIX H

T-TEST OF SIGNIFICANCE FOR PERCEPTION OF ENGINEERING EDUCATED AND CONSTRUCTION EDUCATED RESPONDENTS TOWARD CONSTRUCTION EDUCATION ELEMENTS

		Engineer N=27		Construction N=36		61 Deg. Free		H_0 = 1.671 .05
No.	Elements	Mean	S. D.	Mean	S. D.	T-Value	2 Tail Prob.	
1	Orientation into Construction	1.777	.993	2.08	1.079	-1.18	.244	Accept
2	Specifications & Drawings	2.518	.893	2.64	.639	- .62	.535	Accept
3	Construction Contracts	1.963	.979	2.19	1.037	- .90	.373	Accept
4	Cost Estimating	2.259	.712	2.22	.897	.18	.860	Accept
5	Quantity Takeoff	2.111	.847	2.44	.772	-1.63	.109	Accept
6	Building Materials	1.296	.993	1.72	1.058	-1.62	.110	Accept
7	Contractor Organization and Operation	1.111	1.086	1.58	.996	-1.79	.078	Reject
8	Project Organization and Operation	1.370	1.181	1.63	1.125	- .92	.362	Accept
9	Building Materials	1.851	.907	1.81	.709	.23	.821	Accept
10	Construction Equipment	1.370	1.114	1.72	.778	-1.48	.145	Accept
11	Construction Safety	1.407	1.118	1.91	.840	-2.06	.043	Reject
12	Project Scheduling and Control	2.000	1.000	2.47	.736	-2.16	.035	Reject
13	Construction Economics	2.148	.907	1.86	1.018	1.16	.251	Accept

No.	Elements	Engineer N=27		Construction N=36		61 Deg. Free		H_o = 1.671 .05
		Mean	S.D.	Mean	S.D.	T-Value	2 Tail Prob.	
14.	Cost Control and Analysis	1.777	1.120	2.08	.996	-1.14	.258	Accept
15	Electrical, Mechanical, Plumbing Theory and Design	1.296	.953	1.36	.930	- .27	.787	Accept
16	Electrical, Mechanical, Plumbing Systems: Estimating Coordination	1.296	.823	1.38	1.076	- .37	.711	Accept
17	Systems Analysis and Operations Research	.740	.859	.69	.709	.23	.816	Accept
18	Construction Cost Accounting	1.259	1.059	1.63	1.150	-1.34	.185	Accept
19	Principles of Economics	1.407	.888	1.25	.906	.69	.494	Accept
20	Principles of Accounting	1.370	.838	1.52	.877	- .72	.476	Accept
21	Finance	1.074	.873	1.25	.937	- .76	.451	Accept
22	Insurance and Bonding (Construction)	.925	.916	1.75	.996	-3.36	.001	Reject
23	Personnel Management	1.444	1.120	1.97	.940	-2.03	.047	Reject
24	Labor Law	1.148	.769	1.75	.967	-2.26	.010	Reject
25	Labor Relations	1.259	1.022	1.80	1.009	-2.11	.039	Reject
26	Business Law	1.518	.849	1.88	.918	-1.63	.107	Accept
27	Construction Contract Law	1.814	.962	1.91	1.130	- .38	.798	Accept

		Engineer N=27		Construction N-36		61 Deg. Free		H_o = 1.671 .05
No.	Elements	Mean	S.D.	Mean	S.D.	T-Value	2 Tail Prob.	
28	Fundamentals of Organization and Management	1.481	1.122	2.05	.984	-2.16	.035	Reject
29	Fundamentls of Real Estate	.555	.577	.78	.721	-1.31	.194	Accept
30	Building Codes	1.481	.893	1.80	.950	-1.37	.175	Accept
31	General Physics	1.703	1.137	1.44	.843	1.04	.303	Accept
32	Engineering Physics	2.148	.907	1.44	.998	2.88	.006	Reject
33	Chemistry	1.148	.988	.72	.659	2.05	.045	Reject
34	Geology	1.963	.979	.86	.798	4.92	.000	Reject
35	Graphics: Mechanical	1.777	.933	1.77	.929	.00	1.000	Accept
36	Graphics: Architectural	1.963	1.091	2.08	.769	- .51	.609	Accept
37	Descriptive Geometry	1.963	.939	1.52	.844	1.93	.058	Reject
38	Statistics: Business	1.111	.577	1.13	.930	- .14	.892	Accept
39	Computer Programming	1.296	.775	1.22	.929	.34	.738	Accept
40	Computer Data Processing	1.185	.786	1.00	.894	.86	.395	Accept
41	Algebra	2.444	.933	2.22	.897	.96	.343	Accept
42	Trigonometry	2.518	.849	2.16	.878	1.60	.116	Accept
43	Analytic Geometry	2.000	.960	1.86	.960	.57	.572	Accept
44	Calculus	1.814	1.001	1.30	.950	2.06	.044	Reject

No.	Elelemts	Engineer N=27		Construction N=36		61 Deg. Free		$H_o = 1.671$ .05
		Mean	S.D.	Mean	S.D.	T-Value	2 Tail Prob.	
45	Differential Equations	1.259	.944	.81	.888	1.95	.055	Reject
46	Statistics and Mechanics	2.222	.891	1.83	1.082	1.52	.134	Accept
47	Mechanics of Materials	2.518	.642	2.08	.937	2.07	.042	Reject
48	Properties of Construction Materials	2.518	.700	2.19	.855	1.60	.114	Accept
49	Fundamentals of Structural Design	2.555	.640	2.33	.676	1.32	.192	Accept
50	Structural Design: Wood, Concrete, Steel	2.370	.838	2.25	.769	.59	.557	Accept
51	Soil Mechanics	2.259	.764	1.72	.778	2.73	.008	Reject
52	Hydraulics, Water, Sewage	1.777	.933	1.19	.855	2.57	.012	Reject
53	Foundation Engineering	2.333	.832	1.61	.728	3.66	.001	Reject
54	Concrete Form Design	2.296	.823	2.22	.760	.37	.713	Accept
55	Construction Surveying	2.740	.525	2.61	.687	.82	.418	Accept
56	Engineering Surveying	2.555	.640	1.72	.974	3.86	.000	Reject
57	Earthwork Surveying	2.481	.752	1.97	.940	2.31	.024	Reject
58	Engineering Economics	1.703	.775	1.25	.906	2.09	.041	Reject
59	Advanced Structural Design	.814	.786	.63	.833	.85	.399	Accept
60	Highway Engineering	1.296	.775	1.00	.861	1.41	.164	Accept

		Engineer N=27		Construction N=36		61 Deg. Free		$H_o = 1.671$ .05
No.	Elements	Mean	S.D.	Mean	S.D.	T-Value	2 Tail Prob.	
61	English Composition	2.148	.948	2.27	.701	-.62	.535	Accept
62	Humanities: Literature and Fine Arts	1.037	.758	1.02	.654	.05	.959	Accept
63	Philosophy	1.000	.733	.69	.786	1.57	.122	Accept
64	Logic	1.891	.907	1.58	1.052	1.06	.292	Accept
65	Oral Communications	2.444	.800	2.69	.576	-1.44	.155	Accept
66	Technical Report Writing	2.148	.863	2.00	.985	.62	.536	Accept
67	Professional Ethics	1.888	1.086	1.80	.920	.33	.749	Accept
68	Social Science: History, Government	1.370	.966	1.05	.790	1.42	.160	Accept
69	Psychology	1.444	1.086	1.38	.802	.23	.816	Accept
70	Undirected Elective Courses	1.333	1.074	1.80	1.090	-1.71	.092	Reject
71	Directed Elective Courses Offering Alternative or Advanced Courses in a Major Area	1.518	.975	1.86	.990	-1.37	.176	Accept

APPENDIX I

CONTINGENCY TABLE ANALYSIS FOR THE VARIABLES: ACADEMIC EDUCATION AND LEVEL OF CURRICULAR ELEMENT IMPORTANCE

CONTROL VARIABLE: LENGTH OF EXPERIENCE CHI-SQUARE TEST OF SIGNIFICANCE

APPENDIX I

CONTINGENCY TABLE ANALYSIS FOR THE VARIABLES: ACADEMIC BACKGROUND AND LEVEL OF CURRICULAR ELEMENT IMPORTANCE
CONTROL VARIABLE: LENGTH OF CONSTRUCTION EXPERIENCE
CHI-SQUARE TEST OF SIGNIFICANCE

Chi-Square - 7.82 at .05
Level with 3 df

No.	Element	1-8 Years Experience	Prob.	9-30 Years Experience	Prob.
1.	Orientation into Construction	2.077	.556	5.886	.117
2.	Specifications & Drawings	5.777	.123	2.021	.364
3.	Construction Contracts	3.200	.362	1.425	.700
4.	Cost Estimating	1.666	.645	1.699	.428
5.	Quantity Takeoff	.935	.817	4.050	.256
6.	Bidding procedures	1.605	.658	2.795	.424
7.	Contractor Organization & Operations	4.946	.176	2.035	.565
8.	Project Organization & Operations	4.237	.237	.407	.939
9.	Building Materials	.949	.622	1.812	.612
10.	Construction Equipment	6.666	.083	4.633	.201
11.	Construction Safety	11.822	.008	4.548	.208
12.	Project Scheduling & Control	1.074	.783	3.272	.351

No.	Element	1-8 Years Experience	Prob.	9-30 Years Experience	Prob.
13.	Construction Economics	2.715	.438	4.258	.234
14.	Cost Control & Analysis	1.087	.780	4.295	.231
15.	Electrical, Mechanical, Plumbing Theory & Design	3.822	.281	1.250	.741
16.	Electrical, Mechanical, Plumbing Systems: Estimating, Coordination	5.142	.161	.300	.960
17.	Systems Analysis & Operations Research	1.991	.369	2.198	.333
18.	Construction Cost Accounting	5.643	.130	5.171	.160
19.	Principles of Economics	.933	.817	1.350	
20.	Principles of Accounting	.355	.949	3.153	.360
21.	Finance	.232	.972	5.625	.131
22.	Insurance & Bonding (Construction)	4.606	.203	8.214	.042
23.	Personnel Management	3.510	.319	1.050	.789
24.	Labor Law	3.655	.301	3.000	.392
25.	Labor Relations	2.732	.434	6.825	.078
26.	Business Law	2.333	.506	5.163	.160
27.	Construction Contract Law	4.688	.196	1.285	.733
28.	Fundamentals of Organization & Management	2.715	.438	4.312	.230

No.	Element	1-8 Years Experience	Prob.	9-30 Years Experience	Prob.
29.	Fundamentals of Real Estate	1.600	.659	1.017	.601
30.	Building Codes	3.466	.325	.675	.879
31.	General Physics	5.862	.118	4.142	.246
32.	Engineering Physics	5.206	.157	4.800	.187
33.	Chemistry	.385	.824	2.653	.448
34.	Geology	15.888	.001	4.837	.184
35.	Graphics: Mechanical	2.332	.506	1.548	.671
36.	Graphics: Architectural	3.070	.380	5.327	.149
37.	Descriptive Geometry	4.278	.233	2.250	.522
38.	Statistics: Business	2.435	.487	6.985	.072
39.	Computer Programming	2.977	.395	7.846	.049
40.	Computer Data Processing	2.151	.341	1.992	.574
41.	Algebra	.358	.943	9.400	.009
42.	Trigonometry	1.548	.671	11.892	.003
43.	Analytic Geometry	3.501	.321	3.050	.384
44.	Calculus	6.222	.101	2.625	.453
45.	Differential Equations	.696	.706	1.571	.666
46.	Statics & Mechanics	.851	.604	4.125	.248

No.	Element	1-8 Years Experience	Prob.	9-30 Years Experience	Prob.
47.	Mechanics of Materials	5.140	.162	4.785	.091
48.	Properties of Construction Materials	2.905	.406	3.017	.221
49.	Fundamentals of Structural Design	1.532	.465	3.500	.173
50.	Structural Design: Wood, Concrete, Steel	2.468	.291	2.250	.522
51.	Soil Mechanics	7.208	.066	2.600	.457
52.	Hydraulics, Water, Sewage	7.063	.069	2.330	.507
53.	Foundation Engineering	7.726	.052	6.259	.100
54.	Concrete Form Design	1.938	.585	1.886	.389
55.	Construction Surveying	1.234	.745	.555	.456
56.	Engineering Surveying	6.013	.111	8.346	.039
57.	Earthwork Surveying	2.701	.440	6.009	.111
58.	Engineering Economics	7.930	.047	2.163	.539
59.	Advanced Structural Design	.943	.624	3.911	.271
60.	Highway Engineering	9.407	.024	1.153	.764
61.	English Composition	3.517	.318	2.353	.502
62.	Humanities: Literature & Fine Arts	1.085	.780	.525	.769
63.	Philosophy	2.252	.522	.395	.820
64.	Logic	4.609	.203	.875	.831

No.	Elements	1-8 Years Experience	Prob.	9-30 Years Experience	Prob.
65.	Oral Communications	.717	.698	1.720	.632
66.	Technical Report Writing	2.954	398	1.250	.741
67.	Professional Ethics	4.132	.247	2.812	.421
68.	Social Science: History, Government	1.037	.792	6.825	.077
69.	Psychology	4.630	.201	1.628	.652
70.	Undirected Elective Courses	4.307	.230	1.200	.753
71.	Directed Elective Courses Offering Alternative or Advanced Courses in a Major Area	.855	.836	.853	.836

APPENDIX J

AGC RECOMMENDED CURRICULA

APPENDIX J

EDUCATIONAL GOALS AND RECOMMENDED CONSTRUCTION CURRICULA FOR THE CONSTRUCTION INDUSTRY

Increasingly, the Construction Industry is coming to realize that it will be served best by personnel specifically educated and trained in the managerial and scientific techniques necessary to meet the ever-increasing demands of this rapidly changing technological age. Few industries have more diversified personnel requirements. Professional engineers, business managers, technicians and skilled craftsmen, together form its manpower framework. Probably no other industry is so beset by recurrent personnel shortages at all levels. It is more than obvious that expanded training of manpower is one of construction's most pressing needs.

To this end, the Construction Education Committee of the Associated General Contractors of America desires to set forth education programs which it feels will both meet the needs and enhance the future of the industry. Programs covered here are designed primarily for managerial, supervisory and technical personnel and are to be considered as complementary to those being developed for the training of craftsmen.

Construction Management Education

While the Industry shall always require many persons trained solely as engineers or in the managerial skills, it is increasingly clear that the most effective training for the Industry's leaders at all levels of managerial responsibility is a meaningful synthesis of engineering and business management education at the University level which shall be termed Construction herein and shall entitle one, who satisfies all requirements, to a Baccalaureate Degree. In order to assist most effectively in one's career development, construction education should contribute to these personal qualities:

1) The human understanding to be able to work with all types of people.
2) The discipline to think and reason logically.
3) The technical ability to visualize and solve practical construction problems.
4) The managerial knowledge to make sound decisions and implement them on a prudent economic basis.
5) The facility to communicate these decisions clearly and concisely.

6) The professional stature to provide dynamic leadership in the construction industry and the community.

The curricula recommended here is in broad outline only. The implementation of the curricula and the sponsoring college (Engineering, Architecture, Business, etc.) would depend upon the professional education and experience of the faculty and the educational facilities available at the various colleges and universities.

Whether the course is given in four years or five yars, the percentage mix of the several ingredients of total course content should be approximately the same, but obviously the five-year course should delve more deeply into all areas. An integrated program of engineering, construction, and business is recommended, but this is not to say that worthwhile results may not be obtained by adding a fifth year of business and construction to an undergraduate engineering program.

Construction may be roughly divided into the two areas of:

1) Heavy and Highway Construction
2) Building Construction

While basically educational requirements for the two are the same, it is recognized that the emphasis on engineering science and design should be greater for Heavy and Highway Construction. Other than this, no good purpose is served by stressing differences and from the standpoint of most fully utilizing the capabilities of both faculty and educational institutions, courses should be structured to serve students interested in either area.

For Building Construction, a curriculum is recommended as follows: (Note - percentages, to be regarded as approximations, refer to total course content of 4 or 5 year curriculum)

A) Basic Science - (22%) to include:
  1) Mathematics
    a) Analytical Geometry
    b) Calculus
  2) General Physics
  3) Chemistry or Engineering Geology
  4) Computer - data processing and problem solution
  5) Graphics
  6) Statistics
B) Basic & Applied Engineering - (22%) to include:
  1) Mechanics
  2) Mechanics of Materials
  3) Structural Engineering
    a) Fundamentals of Structural Theory and Design
    b) Soil Mechanics and Foundation Engineering

      - c) Structural Design - Wood, Reinforced concrete, Steel, Aluminum, etc.
    - 4) Surveying
    - 5) Engineering Economy & Cost Analysis
- C) Construction - (20%) to include:
    - 1) Orientation
    - 2) Contracts, Plans & Specifications
    - 3) Cost Estimating & Bidding
    - 4) Construction Operation
        - a) Contractors Organization
        - b) Project Organization & Supervision
        - c) Building Materials & Methods of Construction
        - d) Construction Equipment
        - e) Construction Safety
    - 5) Project Scheduling & Control
    - 6) Construction Economics & Cost Control
    - 7) Electrical Installations
    - 8) Heating, Ventilating & Air Conditioning Installations
    - 9) Mechanical Installations
    - 10) Systems Analysis, Operations Research, etc.
- D) Management - (16%) to include:
    - 1) Economics
    - 2) Accounting
    - 3) Finance including Insurance & Bonding
    - 4) Personnel Management & [illegible] Relations
    - 5) Business Law
    - 6) Fundamentals of Real Estate & Building Codes
    - 7) Organization Management
- E) Socio-Humanistic Studies - (15%) to include:
    - 1) English - Composition & Literature
    - 2) Speech
    - 3) Technical Report Writing
    - 4) Political Science - American Government
    - 5) Social Science
    - 6) Psychology
    - 7) Ethics
    - 8) Electives

For Heavy and Highway Construction a curriculum is recommended as follows:

- A) Basic Science - (22%) to include:
    - 1) Mathematics
        - a) Analytical Geometry
        - b) Calculus
    - 2) General Physics
    - 3) Engineering Geology

- 4) Computer - data processing and problem solution
- 5) Graphics
- 6) Statistics

B) Basic & Applied Engineering - (34%) to include:
- 1) Mechanics & Statics
- 2) Mechanics of Materials
- 3) Structural Engineering
  - a) Fundamentals of Structural Theory and Design
  - b) Soil Mechanics & Foundation Engineering
  - c) Structural Design - Wood, Reinforced concrete, Steel, Aluminum, etc.
  - d) Advanced Structural Design
- 4) Surveying, Earthwork, Principles of Photogrammetry
- 5) Hydraulics, Water and Sewerage
- 6) Highway Engineering
- 7) Engineering Economy & Cost Analysis

C) Construction - (19%) to include:
- 1) Orientation
- 2) Contracts, Plans & Specifications
- 3) Cost Estimating & Bidding
- 4) Construction Operation
  - a) Contractor's Organization
  - b) Project Organization & Control
  - c) Materials & Methods of Construction
  - d) Construction Equipment
  - e) Construction Safety
- 5) Project Scheduling & Control
- 6) Construction Economics & Cost Control
- 7) Systems Analysis, Operations Research, etc.

D) Management - (13%) to include:
- 1) Economics
- 2) Accounting
- 3) Finance including Insurance & Bonding
- 4) Personnel Management & Labor Relations
- 5) Business Law
- 6) Organization Management

E) Socio-Humanistic Studies - (12%) to include:
- 1) English - Composition & Literature
- 2) Speech
- 3) Technical Report Writing
- 4) Political Science - American Government
- 5) Social Science
- 6) Psychology
- 7) Ethics

Large portions of both curricula are engineering. It is recognized that some institutions may find it impractical for reasons of accreditation requirements; faculty experience and interest or institutional facilities to offer Construction in the College of Engineering. In any case, it is intended that the curricula recommended herein be offered with no less rigor than the traditional engineering course of study.

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Paul-Hallbeck and Associates, Architects, Eau Claire, Wisconsin. August, 1956 to August, 1962

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