DISSERTATION

REQUISITE SKILL DIFFERENCES OF BACCALAUREATE GRADUATES AMONG THREE BUILDING DISCIPLINES

Submitted by

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY PAUL A. WEBER ENTITLED: REQUISITE SKILL DIFFERENCES OF BACCALAUREATE GRADUATES AMONG THREE BUILDING DISCIPLINES BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF A PHILOSOPHY.

Committee on graduate work

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ABSTRACT OF DISSERTATION

REQUISITE SKILL DIFFERENCES OF BACCALAUREATE GRADUATES

AMONG THREE BUILDING DISCIPLINES

The traditional project delivery system of design-bid-build is being overtaken by an alternative delivery system called design build. Design build is actually a reemerging discipline dating back to the "master builders" of the renaissance. Design build attempts to, again, blend the two disciplines of design and construction into a single source method of procurement.

The purpose of this study was to explore the differences among architects, constructors, and design builders, in the requisite skills they seek in graduates of design and construction management programs. The literature review recognized skill sets identified by the architecture and construction management disciplines, however, no skill sets were found unique for design builders. A methodology was developed to determine if differences exist among architects, constructors, and design builders.

A mailed questionnaire was sent to 108 architects, 108 constructors, and 108 design builders utilizing a questionnaire containing 32 questions relating to three broad skill sets: (a) architecture skills, (b) construction management skills, and (c) general business skills. One hundred and eighty sets of data were obtained yielding a 56 percent response rate.

An alpha level of .05 was used in making decisions relative to the statistical significance of the results. The results of this study utilizing analysis of variance and post hoc tests showed a statistically significant difference among the professions relating to the three broad skill sets studied.

The data indicated design builders were more similar to constructors than to architects in the skills they seek in graduates. However, design builders valued abilities relating to entrepreneurial skills and marketing skills over that of constructors and architects. All three groups rated problem solving, verbal communication skills, and effectiveness in working relationships as being very important. It was suggested that construction management programs, with modifications, would be best suited to provide the set of skills sought by design builders in baccalaureate graduates.

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CHAPTER I

INTRODUCTION

Background

The construction industry, in response to more sophisticated projects and more sophisticated and knowledgeable owners, has adapted innovative project delivery systems. Chiaverini (1997) defines a project delivery system as the

> "comprehensive design/construction process, aimed at successful completion of the design and construction of buildings and other structures. It includes all the procedures, actions, sequences of events, contractual relations, obligations, interrelations, and various forms of agreement." (p. 9)

The conventional project delivery system used in construction today is called design-bid-build. The project is designed by the designer, an architect or engineer (A/E), then it is put out to bid to contractors. After the contractor is selected, usually the lowest responsible bidder, the project is built by the contractor. Experimental project delivery systems include design-build-maintain, multi-parameter bidding and others (Chiaverini, 1997).

Warkol (1997) claims that most people involved in the construction process feel the current system, design-bid-build, needs to be changed. The conventional process of awarding a contract to the low bidder is not in the best interest of the client. Bids should be awarded on expertise, resources and technical knowledge or problem solving capabilities. The conventional design-bid-build process closes lines of communication by shielding the people who have cost and scheduling expertise used in the later stages of the process (construction) from the early stages of the process (design) where influence over costs has the greatest impact. Johnson (1998), questions whether the designer alone has the expertise to manage the entire process through construction. Involving all parties concerned in the construction process early on, combining the knowledge of the architect, engineer, general contractor, and specialty contractors, may obtain the best results for the owner. Warkol (1997) suggests that all people involved in the construction industry will have to learn and adapt to the shift in the project delivery system paradigm.

The design-build project delivery system has rapidly gained market share in the building industry (Tulacz, 1997). FMI (1998), leading management consultants to the construction industry, predicts that by the year 2005, about 50 percent of construction will be performed utilizing the design-build process. Architects and constructors have expanded services offered to their clients in order to remain competitive, and to improve profits and client relations. As a result of these rapid changes, licensing in these two professions varies from state to state and systemic resistance to new delivery methods lingers. State licensing boards may inadvertently encourage "roadblocks" for combined A/E and construction services (Tulacz, 1997). Architecture and construction education, may be failing to provide the education that meets the demands of the changing business environment. Current education in architecture and construction focuses on traditional courses and seldom, if at all, offers courses that cover topics relating to expanded services. Construction project managers share academic characteristics from architecture, engineering and construction management, which are often viewed as distinct disciplines (Berryman, Jensen & Craig, 1995).

Architects and constructors are increasingly offering design-build services often through contractual relationships with each other. This new design-build entity often is merely the sum of two parts, one part architect and one part constructor. The "master builders" of the pyramids of Egypt and the cathedrals of Renaissance Europe acted as a single source for design and construction responsibility (Beard, 1992; Robson & Bashford, 1995). Design-build firms may have been born in the architecture or construction profession, but are they evolving to a point of almost distancing themselves from one discipline or the other?

The Need for the Study

Little literature exists defining the skills and competencies required of a design-build professional. Often, responsibilities of design-builders are borrowed from the design or construction profession as needed. Entry level jobs for graduates from architecture or construction programs, such as draftsperson or estimator, are often narrow. Later on in their career, more comprehensive skills are utilized and are indispensable. Beyond the technical skills, interpersonal skills become important due to the complex nature of building projects. Do existing contractual relationships between the designer and constructor serve the industry well enough or are people of unique abilities required to build complex projects? In order to address appropriate education for design-build professionals, one can survey the existing industry as a needs assessment of skills and competencies in architecture, construction, and design-build. A new evaluation of requisite architecture and construction management skills should agree with other contemporary studies of the professions. The requisite skills, or fusion of skills, sought by design-builders are uncertain.

The question that would follow is: are there differences in the requisite skills and competencies among the architecture, construction and design-build industries or professions? Competencies and mastery of subjects differ over one's lifetime, so, as a point of reference, industry expectations of baccalaureate graduates from architectural design and from construction programs were determined. The questions asked among the three disciplines (architecture, construction and design-build) relate requisite skills of graduates from formal education programs in architecture and construction.

Statement of the Problem

Owners are increasingly seeking project delivery systems that provide value and avoid conflicts between building professionals. Project delivery systems such as design-build strive to address those issues. Rapid economic and social changes have impacted trends in project delivery which have outpaced responses from institutions ranging from the financial and insurance industries to state licensing boards and educational institutions. Increasingly, the disciplines of architecture and construction are criticized for neglecting to respond to the needs of their clients. The current project delivery system of design-bid-build employed in the building industry is being replaced by the reemerging system of design-build. Often, the design-build delivery system is accomplished by contractual accommodations between the two prime building professionals, the designer (A/E) and the constructor (contractor). A prime motivation for architects and constructors to cooperate are often based on increasing their fees and reducing or shifting risk (Rubin & Wordes, 1997) which offer little to the client or to improving the project. This association may lack an indispensable characteristic of integration. Is there an optimum mix of skills from these two disciplines that may bolster the design-build segment of the building industry? Will we witness the return of the master builder? If so, what paramount skills are required of a design-builder? Restating this as a question to be researched: are there different requisite skills among architects, constructors, and design-builders?

Purpose of the Study

This study investigated the differences and similarities of the competencies and skills required to be employed in architecture, construction, and the design-build industries. The purpose of this study was to determine if there are statistically significant differences among architects, constructors, and design-builders in certain skills they are seeking in college graduates from university design or construction programs. Small differences among the three disciplines would indicate that existing architecture or construction programs provide competent graduates sought by the design-build industry. Large differences in skills required among the three disciplines would indicate that subsequent, specific, courses may be necessary for architecture or construction students to become prime candidates sought by design-builders. Extreme differences in requisite skills among the three disciplines may indicate a lack of cross-over skills or the need for a new program dedicated to design-build. Cross-over skills, such as in business, may be meaningful to examine. Much of the literature that identifies important skills in the disciplines of design, construction, and business, often highly tout interpersonal skills.

Research Questions

Current knowledge areas in architectural and construction education were developed by past questionnaires completed by the practitioners and educators in their respective fields. This study supported those findings but primarily examined differences and similarities between architects and constructors from those of design-builders. Rather than study the practitioner, this study investigated skills the practitioner seeks in graduates of design and construction programs. The practitioners in this study represented the two traditional building professionals, the designer and the constructor, in addition to the reemerging hybrid practitioner, the design-builder. The important questions comprise of highly identifiable skills rooted in the design and construction professions. Cross-over skills, such as general business skills or interpersonal skills were measured due to their prominence in the literature.

The three professional groups studied in this research were architects, constructors, and design-builders. The competencies and skills they considered important were constrained to those skills they seek in baccalaureate graduates. Three sets of competencies and skills were studied in this research: architectural skills, construction management skills, and general business skills. Therefore, the research questions, stated by employing the null hypothesis, were as follows:

Question 1

H_{O1}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "architectural" skills.

Question 2

H_{O2}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "construction management" skills.

Question 3

H_{O3}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "general business" skills.

Delimitations

Architects, constructors and design-build participants were drawn from lists that did not allow the researcher to narrow the market segment in which the professionals primarily work. Dissimilar market segments utilize the design-build method differently. For example, small residential builders and large multinational industrial firms, such as Bechtel, routinely engage in design-build, while commercial office builders are relatively new entrants to the design-build field.

Due to access to comprehensive lists of architects and constructors, which are vast and varied, architects were drawn from an on-line directory, constructors were drawn from a membership roster of the American Institute of Constructors (AIC), and design-builders were drawn from a membership roster of the Design Build Institute of America (DBIA). Membership in DBIA is small and fledgling.

Limitations and Assumption

The study was limited to the design and construction industries in the United States during the late 1990's. Future social, economic and political changes may eventually render this study obsolete as those changes may have promoted the need for this study. It was assumed that participants of the survey answered the questions relating to requisite skills desired of the graduate of their respective disciplines. This included requisite skills of a nonexistent design-build graduate.

It was assumed that the individuals answering the questionnaires understood the skills sought by their companies in newly hired graduates.

Significance of the Study

The acceptance of the design-build project delivery system by owners and the architecture and construction professions has led to its dramatic increase in the building industry. In January 1998, McGraw-Hill touted the start of a new magazine, Design-build, with a notice to advertise headlined, "How to sell to a new $144 billion industry" (Architecture, 1998). The size of the design-build industry is growing. A survey sponsored by the DBIA found that design-build firms experienced a 33 percent growth in revenues from 1996 to 1998 compared to a 25 percent growth in revenues for design/consulting firms (Bright Forecast, 1999).

Criticism of architecture and construction (including civil engineering) programs may stem largely from the rapid change in economic and technological forces that operate independently of the traditions of each discipline. Understanding the competencies still valued in each discipline compared to the competencies valued in the emerging design-build field may offer new wisdom to the traditional disciplines.

Architectural, construction, and design-build firms, in addition to university architecture and construction programs, may benefit from understanding what skills differentiate the architect or constructor from the design-builder. Using the data which measures differences among the three disciplines, existing baccalaureate architecture and construction programs could determine what additional skills and competencies their respective graduates would need in order to position those graduates for employment with a design-build firm. Differences among these three disciplines could guide current architecture and construction schools towards developing design-build specializations or programs.

Definition of Terms

The terms used in this study included the following:

Architect:

"A professional person who is duly licensed by a state (by examination or reciprocity) to perform services in that state involving the design of buildings. Licenses are periodically renewable, are policed to varying degrees by state boards, and our revocable upon beaches of professional conduct. (The term architect is sometimes used generally for any person who designs buildings, but legally one must be licensed to use the term.)" (Dorsey, 1997)

Architect-engineer:

"A term frequently used to designate a design professional when it is not clear which shall be retained, an architect or engineer. AE is the frequent abbreviation to describe a designer or design firm. Very few persons are both architects and engineers." (Dorsey, 1997)

Architectural Skills:

Skills and competencies typically possessed by architects

Architecture Program:

Offering a 4 year, 5 year (professional degree), or master degree in Architecture

Business Skills:

For the purpose of this study, general skills and competencies common to many businesses.

CAD(D):

"Computer aided drafting (and design); a general term for a wide array of operations and techniques." (Dorsey, 1997)

Change Order:

"Amendment to a contract based on a change initiated by the owner, designer, contractor, or building official and documented by a written amendment signed by the owner and contractor after price and schedule adjustments are agreed upon." (Dorsey, 1997).

Code:

"Codes which regulate construction including building codes, fire codes, environmental codes, electrical codes, and zoning codes." (Dorsey, 1997)

Constructability:

"(Sometimes spelled constructibility). A design review process by experience constructors and designers with the objective of establishing during design rational and efficient construction procedures for field execution. The ultimate aim is to cause the designer to adopt materials, systems, and details which are both cost effective and time effective in the field without sacrificing aesthetic intent. Constructability is frequently combined with value engineering as a review process." (Dorsey, 1997).

Construction Management:

"A project delivery system based on an agreement whereby the construction entity provides leadership to the construction process through a series of services to the owner, including design review, overall scheduling, cost control, value engineering, constructability, preparation of bid packages, and construction coordination. In **agency CM** the construction entity is typically retained at the same time as the design team and provides continuous services to the owner without taking on financial risks for the execution of the actual construction. In **at-risk CM** the construction entity, after providing agency services during the pre-construction period, takes on the financial obligation to carry out construction under a specified cost agreement. A guaranteed maximum price is frequently provided by the construction manager in at-risk CM. At-risks CM is sometimes called CM/CG because the construction entity becomes essentially a general contractor through the at-risk agreement". (Dorsey, 1997)

Constructor:

"The term adopted by practitioners who execute construction to define the persons who are responsible for all or part of the building process. In some contracts constructor is used to designate the party directly responsible for the execution of a project." (Dorsey, 1997)

A Constructor is an individual who, through education and experience, is capable of implementing significant facets of construction on a timely and economical basis with proficiency and integrity (Associated General Contractors of America, 1989)

Contractor:

"A person or company who accepts responsibility to perform the obligations of a contract; a term usually applied to one who engages in contract execution as regular employment." (Dorsey, 1997)

Construction Program:

Offering a degree in Construction Management. Conferred in a Construction Management, Building Science, Civil engineering or related programs.

Construction Skills

Skills and competencies typically possessed by managers in construction (not skills of crafts persons or laborers)

Construction Management at Risk:

CM at risk is a project delivery system where the owner contracts separately with a designer and a contractor. The owner contracts with a design company to provide a facility design. The owner selects a contractor to perform construction management services and construction work, in accordance with the plans and specifications, for a fee. The contractor usually has significant input in the design process. (Konchar and Sanvido, 1998)

Delivery Method (delivery system):

"...the approach used to organize the project team so as to manage the entire designing and building process." (p.56) (Gould, 1997)

Design:

"A process of composing ideas and requirements into an understandable scheme or plan for a product. Building design involves architects, engineers, consultants, and sometimes constructors working together to develop drawings and written descriptions (specifications) for a building." (Dorsey, 1997)

Design-Build

Design/build is a project delivery system where the owner contracts with a single entity to perform both design and construction under a single design/build contract. Contractually, design/build offers the owner a single point of responsibility for design and construction services. Portions or all of the design and construction may be performed by a single design/build entity or selected specialty work, or in some cases, all may be subcontracted to other companies. (Konchar and Sanvido, 1998)

Design-Bid-Build

Design-bid-build is the traditional project delivery system in the U.S. construction industry where the owner contracts separately with a designer and a constructor. The owner normally contracts with a design company to provide 'complete' design documents. The owner or owner agent then usually solicits fixed price bids from construction contractors to perform the work. One contractor is usually selected and enters into an agreement with the owner to construct a facility in accordance with the plans and specifications. (Konchar and Sanvido, 1998)

Design-Builder:

Where one entity provides the services of the architect and contractor.

Designer:

A general name for architects and engineers.

Fast-track:

"Compressing the project schedule by overlapping activities that would normally be done in sequence, such as design and construction." (PMI. 1996)

Hard Bid:

"A colloquial term for any agreement where the contractor is at risk not to exceed the fixed price." (p 45) (Dorsey, 1997)

Heavy Highway:

Work relating to Roads, Highways, Bridges, Ship and Air Ports, Canals and Dams.

Infrastructure:

Work relating to Sewers, Utilities and Pipelines.

Life Cycle Costing:

An evaluative process aimed at projecting the costs of building components and operation over time. Factors include capital (initial) costs, replacement costs, maintenance, replacement frequency, durability, an energy usage. The life cycle is the useful life for a building prior to major rehabilitation or removal, usually forty years for commercial building but shorter for hospitals, processing plants, and research laboratories. Different components have different lives, masonry walls been relatively long and some air conditioning components being relatively short. (Dorsey, 1997).

Market Segment:

The building industry consists of many distinct markets. Market segment examples: Residential (single family, multifamily), Building Construction (offices, warehouses, government), Heavy Engineering (dams, tunnels, highways, bridges), Industrial (refineries, heavy manufacturing plants)

Master Builder:

"Part fact and part myth, the individual, usually a master stone mason, who organized and led the design and construction of Medieval buildings." (Dorsey, 1997)

Negotiated Work:

"The process of selecting and arriving at terms of the agreement with a single contractor." The terms are negotiated rather than competitively bid (i. E. lowest price). (Dorsey, 1997)

Owners:

"The party to the contract to has legal possession of the property or who is duly selected to represent the property owner, and who typically provides the financing for the construction. The owner may or may not the primary users of the property. In the case of a public school, the owners are the taxpayers of the district represented by the board of education and the users are the teachers and students." (Dorsey, 1997)

Project Delivery System:

"Project delivery system (PDS): a set of procedures and relationships by which a project is delivered to an owner. The PDS includes the design/construct continuum and can be extended to building maintenance. The PDS determines which parties are responsible for all activities. Various forms of agreement describe the relationships and responsibilities. Salient PDSs include:

1. Lump sum general contracting, which is also called *design-bid-build* to designate the linear process of completing design documents prior to competitive bidding, and which is used to select the contractor who offers the best responsive price. Lump sum is used predominantly in the public sector (and is also called *stipulated sum* in some forms of agreement). A few states require separate contracts for mechanical and electrical work.

2. Negotiated general contracting, which may be based on either a fixed price (lump sum) or a cost-plus a fee, the latter frequently including a guaranteed maximum price; used predominantly in the private sector where negotiations cover a number of issues besides price, such as safety, schedule, construction quality, and performance incentives in any of those or other criteria.

3. Design-build, wherein the design and construction activity are contractually linked, to offer the owner a single point of responsibility for delivering the entire project. Design may be provided by in-house employees, or by one or more consulting firms under subcontract to or in joint venture with the design-build contractor." (Dorsey, 1999)

Value Engineering:

"A design and review process involving critical evaluation of elements of a building to determine the relative value to the owner of the specified product or system compared to alternative products or systems. Life-cycle costing and constructability studies may be parts of value engineering processes." (Dorsey, 1997)

Abbreviations

The abbreviations used in this study included the following:

AIA:

The American Institute of Architects

AIA/CC:

AIA/California Council

AIC:
: The American Institute of Constructors

A/E:
: Architect and/or Engineer (see designer)

ASEE:
: American Society of Engineering Education

BOCA:
: Building Officials Conference of America

CAD:
: Computer aided drafting

CII:
: Construction Industry Institute.

DBIA:
: The Design Build Institute of America

OSHA:
: Occupational Safety and Health Administration

SBC:
: Standard Building Code

UBC:
: Uniform Building Code

CHAPTER II

REVIEW OF LITERATURE

The Search Process

The search process was completed at Colorado State University, Morgan Library, using the Educational Resources Information Center (ERIC), Dissertation Abstracts International (DAI) index, ABI/Inform, Colorado Alliance of Research Libraries (CARL), and COMDEX database. Additionally, the Construction Industry Institute's (CII) "Electronic CII Documents" CD, the Internet, ENR (Engineering News Record) on-line, the engineering library at CU Boulder, the architecture library at the University of California Berkeley, and the engineering library at Stanford University were utilized. Key phrases used were "design-build," "architectural education," and "construction education." Recent journals and periodicals pertaining to architecture, construction and engineering were reviewed. Keyword searches were also performed at UC Berkeley's College of Environmental Design Library in Wurster Hall. Keyword searches were also performed at Stanford's School of Engineering library in the Terman Engineering Building. Acknowledgments of fellow doctoral students found in dissertations located in the Terman Engineering Building were used to track other dissertations in search of topical material and references.

Textbooks were reviewed relating to project delivery systems and the origins of architecture and construction. Construction journals were reviewed for articles relating to design-build. Proceedings from the Associated Schools of Construction dating back to

1990 were reviewed for education, multi-disciplinary education, and project delivery systems articles.

Historical Development of the Design and Construction Professions

Origins of Design-Build

In ancient Mesopotamia, the Babylonian Code of Hammurabi (1800 BC) included a series of amendments to their common laws which placed responsibility for design and construction on a single source, the "master builder." The master builder was the predecessor of today's architect. The word "architect" is derived from the word artificer, which is a skilled worker; a craftsperson. The translation of that Greek word means "a chief artificer, master-builder, director of works" (Mulligan & Knutson, 1999, p. 21). The historical role of the master builder has included responsibility and liability for drafting, engineering, aesthetic design, and construction (Block, 1984). The master builder required knowledge of both architectural design and construction methods. The first recorded penalties that implied liability are found in the Code of Hammurabi. Strict penalties were imposed on the master builder if the client was harmed physically or monetarily. Roman law precluded third party suits limiting the number of the people that can bring a suit, but the "master builder" was still liable for both design and construction flaws (Block, 1984).

The original designer was responsible for both the aesthetics and the structural integrity of the building. As the study of stresses in design and properties of materials grew, engineering became a science of its own. The overlapped responsibilities of aesthetic design and structural design created specialists; today's architect and engineer (Mulligan & Knutson, 1999). Due to time constraints, complex building design, and construction methods utilized during the Renaissance Period, the role of the "master builder" was reduced to design, planning and supervisory control of the construction process. The "builder" became responsible for the erection of the structure. Trade guilds were responsible for marshaling the resources to construct a building, they reported to the master builder which acted more like today's architect/engineer (A/E). These medieval guildsmen were merchants or artisans that formed an association to protect their interests and maintain standards in their trades. Specialization has resulted from societal changes which have altered the role of the builder. Separating the design phase from the building phase has impaired constructability (Mulligan & Knutson, 1999).

Currently, the "traditional" project delivery method is called design-bid-build. Both the design professional and contractor are retained by the owner separately. The three party system (owner-architect-contractor) wasn't devised until the 18th century (Beard, 1992). Members of the American Institute of Architects (AIA) were ethically precluded from providing construction management services prior to 1978 (Block, 1984). The designer (architect, architect/engineer, engineer) prepares plans and specifications. Then, the plans and specifications are sent out to be "bid" by various contractors who then consult with subcontractors for the specialty work. Typically, the lowest bidding qualified contractor is awarded the contract to build the project. The designer will then exercise some degree of inspection, monitoring, or control during construction (Barrie & Paulson, 1992). The architect/engineer, hired by the owner, is expected to represent the client's interest during construction. The owner is expected to provide the contractor with a good set of plans and specifications with which to bid and build. The contractor is expected to build the project at the lowest cost according to the plans and specifications.

Additional project delivery systems have developed with characteristics that differ in contractual relationships, phasing, responsibilities, flexibility, and risks; each having unique pros and cons from the perspective of the owner, architect, and constructor. A few are termed: Construction Manager as Advisor, Construction Manager as Agent, Construction Manager as Constructor, Design-Build by Developer, and Bridging, which is similar to Design-Build, but utilizes an owner's designer separately from the Design-Build entity (AIACC, 1996). The "systems" mentioned above and "joint ventures" can be represented graphically and contractually. Other relationships, alliances, or agreements such as "Partnering" or "Collaboration" have evolved for strategic positioning and risk reduction. Collaboration may occur for reasons of market access, expertise in specialized areas, aesthetic design excellence, project scope, bonding capacity, and other justifications (Dorsey, 1999).

The design-build project delivery method has the owner retain a team of both design professional and contractor in a single contract. There are several contractual models utilized in design-build (Dorsey, 1997). Two primary models are in-house design and consultative design. Other divisions include turnkey, design-build-lease, build-own-transfer, and bridging. In-house design is typically used for routine repetitive projects while consultative design is used for specialized projects. The consultative design-build team may be contractor led or designer led. One problem with this method is that, if mistakes were made in the drawings, who would tell the owner? Similarly, if mistakes were made in construction, who would tell the owner? By having two separate entities, checks and balances would exist to protect the owner, much as three branches of government exist to act as a check and balance.

Residential construction has used the design-build method for many years; however, it is not necessary to have an architect design a residence. Highly specialized segments of the construction industry, such as oil refineries and power generating plants, also have used the design-build method for years. Building in commercial construction markets, such as office buildings and shopping centers, traditionally, has been accomplished employing the design-bid-build process.

The practice of architecture in the mid-1800's was in the process of becoming a profession, which included issues of formal education, apprenticeships and licensing. After the Civil War, there was a considerable demand for reconstruction and architects (Robson & Bashford, 1995). The industry questioned the practice of design-build because there were no apparent safeguards to protect the interest of the owner. One of the attributes of professionalism is to place the interests of the client and society above the professional's interests. Over time, the relationship between the architect and constructor has become adversarial. When bids came in too high or when problems would arise during construction, each side, the architect and contractor, would blame the other. Lawsuits multiplied and owners were caught in the middle of the fight. Errors and omissions insurance rates for architects have increased to the point where many architects go "bare," which is to say they carry no professional liability insurance. Professional liability insurance for contractors, too, has risen. The industry's image has suffered and many owners, weary of the conflicts, are seeking an alternative. Architects and constructors have teamed up to strategically reduce risks and litigation and to increase fees (Collingsworth, 1997). Increasingly, the alternative is towards contractual arrangements such as design-build or other pacts, such as "partnering," where adversarial relationships are reduced or eliminated and "open" relationships are developed. Personal integrity is favored over a written contract. The owner, for example, would know the cost and profit the design-build firm makes, whereas, in the design-bid-build process, that information was highly guarded.

Benefits of Design-Build

Increasingly, the design-build project delivery method is being embraced and preferred by owners (Chiaverini, 1997). Krizan (1997) cites Construction Industry Institute (CII) research that indicates this method reduces overall costs and shortens the construction schedule. Design-build growth has come at the expense of other project delivery systems. Owners are tiring of the costly and time consuming process of selecting architectural and construction teams ("Design-build contracts spreading in industry," 1993). Sullivan (1997) discussed a trend by owners looking for fast-tracked, low-cost building projects.

A study of 350 projects by the Construction Industry Institute measured costs, schedule and quality of design-build projects and compared them to the conventional design-bid-build project delivery system. The results indicated that design-build offered cost and schedule savings. The results also indicated that the differences in reported quality were relatively small (Krizan, 1997) A later study of the original data concluded design-build offered better quality results (Konchar & Sandivo, 1998). Friedlander and Roberts (1998) reported the benefits of the design-build approach include shortened project delivery time, single point responsibility, minimized claims and changes, performance warranties, increased potential of packaging other services, and continuity between designer and constructor.

Cost escalation of design-bid-build is 4.84 percent, compared with 3.34 percent for construction management (CM) and 2.37 percent for design-build. CM and design-build projects had almost no schedule delays compared to an average of 4.4 percent for design-bid-build according to a CII study (Krizan, 1997). Turnaround time for shop drawings and RFI's are reduced (Hartman, 1997).

Popcock (1996) studied project performance on 209 projects to measure the *degree of interaction* (DOI) among designers, builders, and project team members during project planning, conceptual design, detailed design, procurement, and start up phases. Popcock concluded that among various project delivery approaches, partnering, design-build, constructability, and concurrent engineering benefited by:

> "...putting the right people on a project team, including both designers and builders. Beginning interaction in the early project phases and spanning the design/construction interface, and building regular, planned interaction among all project team members into the normal way doing business" (p. 104).

Some benefits of the design-build delivery method are shorter overall project duration and lower project cost which can occur through integrated design, procurement, and construction activities. Alternative materials and methods, value engineering, and constructability are used continuously during the design-build process as opposed to intermittently with the traditional design-bid-build approach (McCullagh, 1997). Williams (1997) reports that deign-build lowers owner's risk exposure due to a single point responsibility for design and construction This yields fewer claims compared to having several parties involved, involves fewer change orders, contains lower owner administration costs, delivers improved quality and better warranty service, improves constructability since the constructor is also the designer, and enhances flexibility when issuing change orders.

Owners Preference for Design-Build

Owners are demanding higher levels of performance and accountability in the building process (Neenan, 1997). They are requiring "better, faster, safer, cheaper" products and services which is redefining the methods of procurement and delivery (FMI, 1998). Corporate downsizing has affected engineering, construction, and facilities management departments which means they no longer have the staff to handle "unbundled" services (Tulacz, 1997). The traditional design-bid-build project delivery system is relatively inflexible due to multiple entities and points of contact. Design-build offers the owner better upfront feasibility analysis, collaboration among a multitude of building professionals, early construction cost and schedule guarantees, overlapping design and construction activities, and a single point of responsibility and accountability (Neenan, 1997).

In lieu of price alone, owners can make decisions based on an entity's qualifications, technical approach, and price in determining value. Low bid entities can be perceived as having a short-term perspective, where the client's happiness and the project's success comes second to making a profit as a low bidder. Design-build entities look to build long-term relationships with satisfied clients (Markus, 1997). Owners wanting less "project-team" controversy are looking for new delivery systems and team arrangements to ensure control over cost and schedule (Ellickson, 1996). Owners increasingly want an out-sourced, single source, integrated contract. They are tired of disputes under the traditional design-bid-build method (McCullagh, 1997).

Owners and developers searching for ways to reduce costs and to increase speed and cost effective design are searching for alternative delivery systems (Block, 1984). Owners increasingly are embracing the design-build service, but, this "profession" does not have its own licensing or education standards. George Heery, FAIA, has coined a term, "bridging," which describes a bridging consultant that works with the designer and constructor (Appelbaum, 1998). This bridging consultant is sometimes part of the owner's staff.

Corporate downsizing has increased the need for design-build. Separate real estate and construction departments have been eliminated in companies that are re-engineering and focusing on "core" activities. Outsourcing to a single source of responsibility is favored (McCullagh, 1997). During design and construction, the owner does not have to coordinate separate design and construction contracts. Guaranteed construction costs are established 60 percent earlier in the design-build method compared to the traditional design-bid-build method (McCullagh, 1997). Change orders due to errors and omission are eliminated because the builder has the responsibility for developing the drawings and specifications as well as the building (McCullagh, 1997).

Historically, public agencies have awarded projects to lowest responsible bidder, but it is increasingly thought that design-build is "more conducive to creative problem solving" (Markus, 1997). Federal owners charge that architects/engineers don't provide sufficient attention to constructability and maintainability issues. They see shorter schedules and adaptations to change and fewer legal problems with design-build. They are looking at total value, quality, functionality, aesthetics, maintainability and life-cycle costs (Beard, 1992). Local governments are shifting from the traditional method, which was considered the best way to prevent collusion and favoritism, to alternative models which are increasingly thought of as being more cost-effective and more conducive to imaginative problem solving (Markus, 1997).

Architects Preference for Design-Build

Clients, contractors, or other members of the construction team bring 70 to 75 percent of all claims brought against the design profession. Claims would be reduced under the design-build approach (Collinsworth, 1997). Clients are hiring design services at lower costs from interior designers, engineers, contractors, and construction managers (Gutman, 1996). Sociologists sometimes refer to architecture as a "weak" profession because of a lack of economic and political power. Ellickson (1996), quoting AIA Document Task Force Chairman Denny Guidroz, wrote "we need a cultural shift in the profession... we must assume a broader role with the private client... that may mean taking on more rather than less responsibility..." (p. 19).

As owners increasingly place less importance on aesthetic value and more on construction cost and schedule, architectural fees have been squeezed. Architects are seeking ways to produce revenue in other related areas such as construction management, but this, too, has become a battle. Ellickson (1996) charged that construction managers, design-builders, facilities managers, interior designers and others have encroached on the role of the architect. A construction manager may schedule, coordinate, inspect, and make payments to subcontractors and suppliers; their functions overlap those of the architect and contractor (Block, 1984). Eighty percent of design-build projects are contractor led and 20 percent are architectural/engineering led (Collinsworth, 1997).

Buchanan and Gravallese (1995) believe that, as the market place becomes more challenging, architects should use their contract position, typically the client's first contact, to expand their services. This strategy has worked in the software industry where Microsoft's dominance in the disk operating system market has allowed it to have a head start in applications software.

A single source of responsibility for both design and construction allows one entity to control quality, cost and schedule. It is up to the design-builder to warrant, to the owner, that the design documents are free from error as opposed to the owner warranting the same to the contractor in the traditional design-bid-build approach (McCullagh, 1997).

Constructors Preference for Design-Build

Tulacz, (1996) wrote that construction executives perceive risk as being the primary element in evaluating project delivery systems so they regard design-build as "a natural evolution from CM" (p. 33). Communication between the design and construction phase reduces design time, allows for fast-tracking, expedites long lead items, and improves constructabilty and value engineering (Gould, 1997). Complex projects and projects difficult to define can better integrate design and construction in order to realize a schedule or budget by utilizing design-build; fewer changes, delays, disputes, and claims arise (Dorsey, 1997). Public owners are more willing to embrace design-build which has steered more firms into the design-build market (Tulacz, 1998).

Issues with Design-Build

"Design-build is not the panacea that many people once saw it as" says Robert McCoole, president of J.S. Alberici Construction (Tulacz, 1997, p. 48). Drawbacks with design-build include loss of checks and balances, less owner control, enmeshed competitive bidding, and institutional obstacles (Friedlander & Roberts, 1998). Since contractors typically fill the design-builder role, owners lose direct communications with the designer (Appelbaum, 1998). Owners may not have in-house staff qualified to administer design-build contracts and cost guarantees can inhibit creative problem solving or the scope may creep after a cost guarantee (McCullagh, 1997).

The architect has different motivations to analyze construction problems in a design-build delivery system which may not be in the best interest of the owner (Dessau, Hurley, & Pak, 1997). The traditional checks and balances are gone. The architect's allegiance is to the builder, not the owner (Hartman, 1997). Surety companies are reluctant to assume risk of the prime contractor to the owner (Dessau, Hurley, & Pak, 1997). Capital, capacity, and character requirements of bonding companies differ greatly between architects and builders. Tulacz (1998), cites Jeffery Beard, executive director of the Design-Build Institute of America, referring to contemplated state enacted qualification-based selection laws, noted that some designers perceive "design-build legislation as a threat" (p. 55) and have directed their lobbyists to suppress the legislation.

Issues in the Professional's Education

Architectural Education

Current criticism of architecture and construction programs may be due to expanded services offered by architecture and construction firms, when pressed by the market, that occur without the education and strategic planning necessary to provide these new services. Harrigan and Neel (1996) emphasize that critical gaps exist in educating the designer that needs to be addressed; and the architecture profession has been criticized as "failing the schools" (Kroloff, 1996, p. 92). Graduates lack technical proficiencies to the point that "many practitioners feel they are worthless" (Kroloff, 1996, p. 92).

About 130 years ago, architectural education shifted from technical and trade schools to the universities. The tradition of apprenticeship was eventually "codified" in 1978 with the Intern Development Program. Architectural education typically consists of two parts; college followed by an internship. Princeton's Alan Chimacoff notes there is a critical difference between someone who is well educated and someone who is well trained. The former can resist social, economic and cultural changes; the latter may be more useful initially, but their training becomes obsolete (Kroloff, 1996). Emphasis on design in architectural education result in students who lack know-how in building technology and construction (Gutman, 1996). Design opportunities right out of college are limited because most of the design jobs are held by seasoned, senior staff causing frustration for graduates. Gutman notes that the scope of architecture, as a discipline, is expanding faster than universities can adapt. Design schools don't feel the market pressure that architects feel. When architects and contractors expand their services, they often encroach into the other's traditional territory. Gutman (1996) says "we are on the brink of a fundamental transformation of the basic structure of architectural education..." (p. 89). He sees the profession in need of rescue.

Gordon Chong, FAIA, past president of the AIA/California Council (AIA/CC), declares there is clear evidence that architects have been moving beyond traditional practices as evidenced in the AIA/CC's newly published handbook on project delivery which identifies seven alternatives to the standard design-bid-build service delivery (Hobbs, 1996). An AIA survey of architectural firms indicated that the percentage of firms' net billings relating to "construction services" has increased to 18 percent in 1997 from 5 percent in 1991 and that 23 percent of firms offer design-build services. In 1996, just over 40 percent of net billings can be accounted for from expanded services (Baker, 1997).

Hobbs (1996) wrote we should "change from thinking in terms of a project delivery to defining service delivery" (p. 12). Princeton University lecturer and consultant Robert Gutman laments that, because of the university system's requirements, students are learning a fraction of the knowledge and skills required in any period since professional programs were established 130 years ago (Gutman, 1996). Architecture's historic value is being eroded. A Carnegie Foundation study has criticized colleges for not making architecture and design part of a liberal education for all students (Hamlin, 1996).

Construction Education

The first identifiable construction program in the U.S. started at the University of Florida in Gainsville in 1936. Construction programs have sought recognition as an academic discipline on par with the architecture and engineering disciplines. Those disciplines recognized the need to separate themselves from the manual process of construction (Robson & Bashford, 1995).

In 1971, the American Institute of Constructors (AIC), by its formation, embarked on defining a constructor. Construction, to be accepted as an academic discipline and a profession, may have to go through the same struggles as the architecture and engineering disciplines. The definition of constructor needs to be clarified and the discipline should have rigorous academic standards based in theory and have influential professional organizations (Robson & Bashford, 1995).

Construction programs have historically been driven by industry and not by theory. Too often, programs were established to specifically address regional needs. This resulted in fragmented programs which reflect the fragmented industry. The academic standards increasingly demand more management of the construction process and less "trade school" knowledge. Robson and Bashford (1995) caution, though, that too much emphasis on theory may cause erosion of industry support.

Due to the litigious nature of the industry, architects and engineers have increasingly shed their management responsibilities, creating a void, which the constructor has had to fill. This has elevated the position of the constructor and education is being called on to address this. The demands in today's economy and demands by owners require the constructor to be involved in the construction process early on (Robson & Bashford, 1995).

Will design-build always be a profession derived from a marriage of convenience between the architecture and construction fields, or will it develop as a stand-alone discipline? Where do the project mangers for design-build firms come from; the design or the construction schools? Most likely, both. A recent article in U.S. News and World Report, titled "20 Hot Job Tracks" (1998), lists construction project managers as a "hot track" job. The article noted the training which most construction companies prefer. They listed a degree in engineering, construction management, or architecture with a solid background in management, knowledge of contracts, building and environmental regulations, computerized cost-accounting, scheduling, and design. Additionally, good communication skills helped. A recent study of construction companies rated oral and written communication higher than scheduling, estimating and use of spreadsheets as skills sought from construction graduates (Chini, Fauvell, & Coble, 1997).

Cecere (1998), in the rationalization of an Associated General Contractors of America (AGC) study, included "rapidly changing occupational requirements" (p. 1), specifically computer communications. If rapid changes in computer communications should be considered in successful construction education programs, it can be argued that rapid changes in project delivery systems should be addressed.

Mead and Gehrig's (1995) first round of Delphi interviews corroborated with other literature a need for communication, computer, and business management skills beyond specific construction management skills. Rounds (1992) stressed creative thinking, critical analysis, communication skills, and the ability to learn. Rounds added that integration of the construction curriculum will require working with designers because of constructability issues and the industry's need to work in "real time."

Civil Engineering Education

A 1994 report from the American Society of Engineering Education (ASEE) states that industry recognizes the need for different type of engineer, one with a broadened engineering education which includes team skills, communication skills, leadership, a systems perspective, and a multidisciplinary perspective (Farr, 1997). The report calls for the skills to be integrated into existing curricula and non-classroom activities, not through separate courses.

Theis (1996) remarks the trend in "design-build-operate" or "finance-design-build-operate" has become so complex that a team of specialists is required. New criteria presented by the Accreditation Board for Engineering and

Technology (ABET) (the ABET 2000 criteria) shifts the emphasis from what is taught to what is learned. If engineering practice continues to evolve towards marked-based, team oriented systems where social skills are as important as technical and problem solving abilities, there is a question of how education should assess the outcomes in coursework.

Peter Staudhammer, TRW, Inc. vice-president for science and technology at a gathering of the National Academy of Engineering (NAE), expressed the need for engineers who can lead teams, reduce cycle time and understand the total enterprise. William Powers, vice-president for research at Ford Motor Company, stated that "we are moving from the component engineering world of yesterday to the natural systems engineering world of tomorrow" (Morgan, Reid, & Wulf, 1998, p. 16). Bordogna (1998) stressed that engineering education should be "shaped by society's increasingly integrated, complex civil systems and the engineer's task as society's master integrator" (p. 48). He believes that engineers should work in teams, communicate well and be able to view their work across disciplines. He criticized graduate programs for being reductionist and too focused towards the industrially oriented engineer. He called for curriculum that offers broader career opportunities and stronger ties to industry and the wider community.

Grigg (1999), responding to Bordogna, affirms the position of civil engineer acting as a synthesizer on a multidisciplinary team but questions this view on large-scale projects. He wonders how "to identify the unique skills that civil engineers can bring to different types of problems" (p. 67) and what integrative skills are needed. He concured with the need to "enhance the ability of civil engineers to synthesize solutions, rather than just design technical components" (p. 67). Beder (1999) emphasized broader skills, she appears to characterize as social skills, that calls for engineers to consider social context in order to determine the appropriate technical solution. Beder cited surveys and even cartoons highlighting engineer's perceived lack of interpersonal skills which affects the industry from recruitment to being overlooked for management positions. Beder cited Samuel Florman's 1976 book, "The existential pleasures of engineering" that blamed engineering schools for snuffing out imagination, social concerns and cultural interest under "a crushing load of purely technical subjects" (p. 14). Because of the respect that science has gained, Beder (1999) stated "the need to teach science in engineering schools has been grossly inflated by the needs of the engineering profession for esoteric knowledge and those of engineering educators for academic respectability" (p. 15).

An intriguing question arises: what type of person chooses to become an engineer and why? It may be simplistic, but convenient, to view requisite skills and competencies of any profession along a technical and social continuum. One's personality or demeanor may favor a career whose requisite skills and competencies appears, by stereotype, to lie somewhere along the continuum. The dilemma, highlighted by Beder, is how we can educate on a part of the continuum that recruits purposely avoid.

Towards Interdisciplinary Education

Emphasis on alternative project delivery systems through multi-disciplinary education attempts to increase understanding across disciplines. Students become aware of the needs of other disciplines and the importance of effective communication among the disciplines (Robson, Caldwell, & Reynolds, 1996). Linked sections of design and construction, co-requisite classes, and classes taught by visiting professors have been put forth (Wendler & Segner, 1989). Farr (1997) cited an ASEE report which proposes broadening engineering education to contain a multidisciplinary perspective as well as team and communication skills. Mead and Gehrig (1995) add that "people skills," leadership skills and broad business skills are needed.

Past Research

Architecture and Construction Education

Architecture competencies and skills have been studied by the Carnegie Foundation (Boyer & Mitgang, 1996). Construction management competencies and skills have been studied by organizations (AIC, 1994) and educational researchers, (Cecere, 1998: Chini, et al., 1997). Mead and Gehrig (1995) utilized a delphi technique asking a panel of experts to identify changes in the construction industry.

The instruments reviewed include the survey instruments that resulted in The Carnegie Foundation for the Advancement of Teaching's book; "Building Community, A New Future for Architecture Education and Practice" (Boyer & Mitgang, 1996). CII's "The Acquisition of Skills and Traits Among Construction Personnel" (Dorsey, 1990), the Learning Outcomes Template utilized at Virginia Tech (Auchey, Mills, & Beliveau, 1997), and the AIC Constructor Certification Skills and Knowledge Survey also were reviewed.

Design-Build

Popcock (1996) studied the relationship between alternative project approaches, and their integration and performance. Molenaar (1997) developed a model for project selection for public sector design-build. Molenaar cites five theses relating to design-build in the public sector. The articles reviewed addressed the benefits and weaknesses of design-build as a project delivery system. This researcher is not aware of studies addressing the skills and competencies required of design-builders. Articles touting interdisciplinary education in architecture, construction, and civil engineering detail a broader perspective including teamwork (Bordogna, 1998; Chini, et. al, 1997; Carter, 1996).

General Business Skills

Questions relating to architecture and construction management competencies were combined with "general" skills identified, for example, by Mead and Gehrig (1995). The questionnaire developed included skills identified in the disciplines of architecture, construction management, as well as general business skills that don't belong exclusively to either domain. There are many cases in the literature citing the need for "soft skills' or general skills that cross disciplines (Bordogna, 1998; Beder, 1999; Chini, et. al., 1997; Grigg, 1999; Morgan, et. al., 1998; Mead & Gehrig, 1995; Rounds, 1992; Theis, 1996; Young, 1989)

Summary

The history of design and building was examined. Development of the professional specializations and their respective education were examined. Requisite competencies and skills in architecture, construction management, broadened to include (civil) engineering, were examined. Instruments developed for Architecture and Construction education were reviewed.

CHAPTER III

METHODOLOGY

Research Design

The research design and procedures that were used in conducting this study are outlined in this chapter. A survey design was used to sample a population in order to generalize the findings to a population. A survey was used due to the economy of the design, the quickness of the data collection, and the ability to identify attributes of a population (Creswell, 1994). This study is cross-sectional (collected at one point in time) and was mailed to respondents due to convenience and relatively low cost. The design of the instrument is similar to a recent survey by the American Institute of Constructors (AIC, 1994) sent to their own members, among others, regarding the desirable skills and competencies they require in graduates of construction programs.

This multi-stage sampling design drew samples from three groups of building professionals: architects, constructors, and those who identified themselves as design-builders. The three different professional groups represent the independent variables of the research questions.

A panel of experts in architecture and construction were contacted in order to add to previous questionnaires described in the literature review and to help form the final survey instrument. The list of the Panel of Experts is contained in Appendix A. Through the literature search and suggestions from the Panel of Experts, a list of skills and competencies were developed . A Cover Letter (Appendix B) accompanying a

Preliminary Survey Instrument (Appendix C) was sent to the panel of experts who were asked to review the instrument for face validity and provide suggestions for its modification. After reviewing the feedback from the panel of experts, the final list of skills and competencies were developed (Appendix D). The list was arranged by three prime constructs which emerged from the literature and from the panel of experts. The three prime constructs are skills relating to architecture, construction and, for the lack of a better name, general business skills. The general business skills are those that would not readily be identified as solely an architecture skill or a construction skill. The general business skills are more often "soft skills" which are not the province of architecture or construction.

In order to encourage thoughtful answers, the arrangement of the questions were randomly reordered as suggested by Salant and Dillman (1994). The fourteen skills relating to architecture, the nine skills relating to construction, and the nine skills considered general business skills, as listed in Appendix D, were assigned a consecutive number as shown on the left. These thirty-two questions were rearranged randomly utilizing a spreadsheet. A new sequence for the questions was established and is indicated on the right side of the questions found in Appendix D. For example, the last question pertaining to architecture skills (No. 14), the ability to use CAD, is skills question number 30 of the survey instrument.

Prior to mailing the questionnaires, approval of the study by the Colorado State University Human Subject Review Committee was obtained. A series of questions were answered (Appendix E) and submitted with the proper application form, a copy of the final instrument and the proposed methodology. The approval form from the Human Subject Review Committee is found in Appendix F.

Population, Sample, and Sampling Design

The DBIA 1998 Membership Directory includes 273 corporate members, of which 108 identify themselves principally as design-builders. Therefore, the sample size of the of architects and constructors was based on the accessible population of 108 design-builders. The sample size consisting of 108 architects, 108 constructors, and 108 design-builders made it convenient to number each instrument in order to facilitate follow-up of non-respondents, thereby increasing the response rate.

The random selection of architects and constructors on a state by state basis would have been overwhelming by employing the registration or licensing data of all fifty states. The selection of the 108 professionals from each discipline was as follows.

The Selection of Architects

Since selecting architects representing every state in the nation would be an formidable task, regions were utilized to represent the nation and pare the work. The six regions, as designated by the Associated Schools of Construction (ASC), were used. The regions were given a number and are shown in Figure 1.

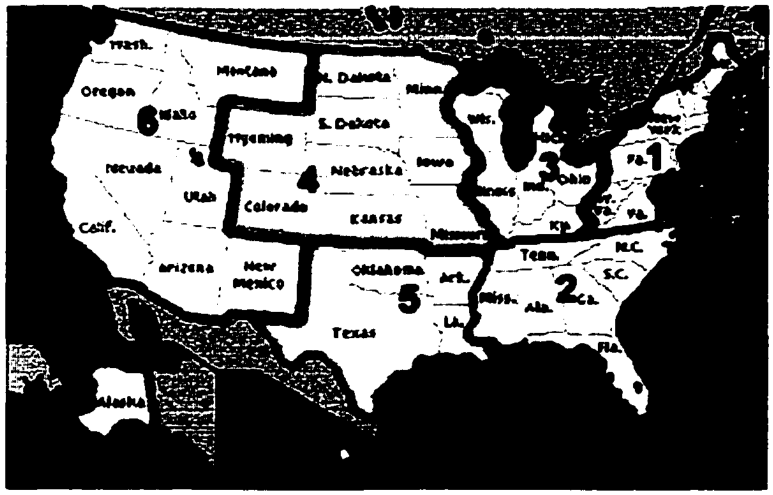

Figure 1. Map of the Six Regions of the Associated Schools of Construction

The most populous state of each region was used. The population of each region was not expected to be exactly one-sixth of that of the nation so a proportional sample was determined. The population of each state was obtained from the U.S. Census Bureau off the Internet (available on line:http://www.census.gov/population/Estimates/state/ ST9097T1.txt). The data were dated July 1, 1997 and recorded in Appendix G. The population of each of the six regions of the ASC were calculated and the percentage of the total population is shown in Figure 2.

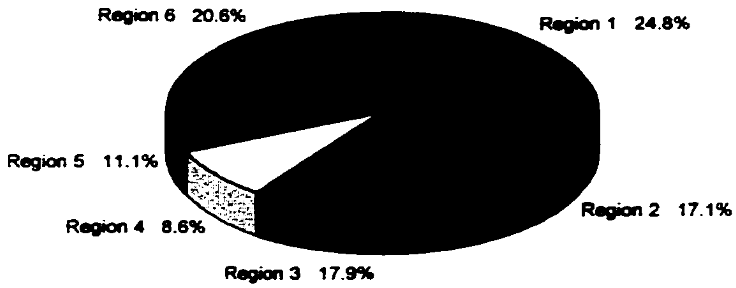

Figure 2. The Percentage of the Population of the Six Regions of the Associated Schools of Construction

The populations of each region, the percentage of the total population they represent, and the sample size required, given a total sample size of 108, from each region are listed in Table 1.

Table 1

General Population and Sample Size per Region of the ASC

ASC Region		% of Population	Sample Size 108
Region 1	Northeast Region	24.8	27
Region 2	Southeast Region	17.1	19
Region 3	Great Lakes Region	17.9	19
Region 4	North Central Region	8.6	9
Region 5	South Central Region	11.1	12
Region 6	Far West Region	20.6	22
	Total	100[a]	108

[a] Total is rounded to 100

Due to rounding errors, the total would have been 107, so the data were analyzed to see which figure was the largest when rounding up. Region 2 met that criteria and is entered as 19 instead of 18.

The most populous state in each of the six regions was selected. For example, in Region 6 of the ASC, the Far West region which represents approximately 21 percent of the total population, California is the most populous state (Appendix G). Twenty-two architects were selected from California. California has over 20,000 registered architects, consequently, counting every 185th architect on the list would have been a time consuming task. Other approaches were sought and a discussion can be found in Appendix H, Selection Process for the Architect Database.

Construction Market Data (CMD), a consulting firm to the construction industry and a business partner of the AIA, has produced a database called "ProFile" available on the Web (http://www.cmdg.com/profile/). This search engine for locating architecture firms in the United States was used because of its size and speed. The total number of firms listed in California was 1,300 as indicated at the top of the displayed search page. This number was large enough, but manageable enough, to perform a systematic count for the necessary sample.

The total number of ProFile listings for each state representing the six ASC regions was determined while on-line. The sample size required from each region was applied to determine the selection of every "nth" architect on the list. A random number, between one and ten, was drawn to make the selection of the first architect on the ProFile list. Every "nth" architect subsequent to this was selected. For example, since there are 793 architectural firms listed in the ProFile directory of the State of New York, and 27 firms need to be selected, every 29th architect was selected for the survey (see Table 2). The calculation for the nth architect was rounded down so the systematic count of the last architect would not exceed the list's capacity.

Table 2

The nth Architect Selected from Represented States

ASC Region	State	No. Of ProFile Listings	Sample Size	nth architect col. 3/ col 4
1	New York	793	27	29.37
2	Florida	523	19	27.53
3	Illinois	502	19	26.42
4	Missouri	223	9	24.78
5	Texas	616	12	51.33
6	California	1.330	22	60.45

The selection took place while on-line so the sample architect's name. address. phone number. and e-mail address was copied and pasted to the database file. This facilitated developing the mailing database as well as follow-up communications by telephone or e-mail.

The Selection of Constructors

The sample of constructors would have proved to be as laborious as that of the registered architects if the sample were selected from state licensing databases. so another approach was used. The sample population of constructors are members of the American Institute of Constructors (AIC) listed in their 1998 Directory of Members. A systematic sample of 108 of the 799 members was accomplished by selecting every seventh member from the directory. The selected individuals were reviewed by Dr. Allan Hauck, a member of AIC. to eliminate educational members or vendors from the sample. If a selected member was deemed inappropriate. the following posting was utilized in place of the rejected member.

The Selection of Design-Builders

The population of member firms of the Design Build Institute of America (DBIA), in their 1998 Directory of Members, includes 273 corporate or associate corporate members with 108 members identifying themselves primarily as design-builders, rather than Architects/Engineers or Constructors. All 108 DBIA members that identified themselves primarily as deign-builders were selected.

Response Rate

A survey in 1994 by the Carnegie Foundation for the Advancement of Teaching reported a 47.6 percent overall response rate from administrators of professional architecture programs in the United States. The eleven page questionnaire contained 60 questions. A nine page, 49 question, survey sent to alumni had a response rate of 41.1 percent (Boyer & Mitgang, 1996). The survey instrument in this research is smaller, consequently it was less time consuming and more convenient to respond to. Tracking numbers placed on each instrument allowed the researcher to make follow-up inquiries by phone or e-mail in order to increase the response rate.

Instrument Development

A preliminary instrument was developed and reviewed by a panel of experts. Dependent and independent variables were selected from multiple sources. Previous questionnaires developed by the American Institute of Constructors (a questionnaire for constructors) and the Carnegie Foundation for Teaching (a questionnaire for architects) were reviewed. A survey sent to members of the Design-Build Institute of America (DBIA) and an on-line survey (http://www.construction.com/survey/) called the Education Forum Futures Survey, a project associated with the American Council for Construction

Education (ACCE) were also reviewed for demographic variables. Additionally, a reader profile of the American Consulting Engineer (available on-line: http://www.acec.org/ programs/acerdpro.htm) was reviewed.

Job postings for architectural graduates found at the University Colorado, Boulder and on-line job postings by the Colorado Chapter of the AIA (AIA Colorado Job Board: http://www.aiacolorado.org/jblist.html) were reviewed. Job postings for constructors available at the Phelps Internship and Placement Program at Colorado State University were also reviewed.

There were two open-ended questions sent to the panel of architecture and construction experts. Some responses from building professionals slow in responding to the initial questionnaire were obtained in face-to-face interviews, telephone calls, e-mail and through the U.S. mail. The two open ended questions posed were phrased according to the type of respondent. For example, the questions posed to constructors were: (a) What skills, traits and competencies do you think are important for graduates of a construction management program?, and (b) Do you feel undergraduate construction education is not responding to the needs of the construction profession? If so, please explain. The last question was an attempt to have the respondent react to technical skills related to the discipline as opposed to soft skills or character. The latter character traits were often submitted by the respondents and is corroborated by a lot of literature.

A Preliminary Survey Instrument (Appendix C) was developed and reviewed by the Panel of Experts. An open-ended question near the end of the questionnaire provided an opportunity for the participants to state their view regarding additional or alternate skills and competencies.

The final list of skills or competencies reflect the two primary disciplines of architecture and construction and a third set of skills or competencies were termed "general business" (Appendix D). Each skill or competency, as a variable, was restated into a question, all on a positive scale, and then exported to a spreadsheet where random numbers were assigned to each question. The spreadsheet was used to resort the questions in order to mix the questions randomly.

Only two members of the Panel of Experts, both architects, indicated they did not understand a question relating to construction. Those questions were rephrased in the final draft of the questionnaire. The instrument is not too laborious to answer which contributed to a respectable response rate. The architects reported an average of 8 minutes and the contractors reported an average of 9.2 minutes to respond to the preliminary questionnaire.

To ascertain if there were rational differences between architects and constructors in responding to the preliminary questionnaire, the researcher, arbitrarily set a difference of 2 points on a 7 point Likert scale, found there were differences between architects and constructors. There were differences regarding 2 questions (questions 19 and 30) that were primarily architectural skills, 6 questions (questions 14, 22, 23, 27, 31, and 32) that were primarily construction skills and 2 questions (questions 4 and 8) that were categorized as general business skills. The use of the Preliminary Survey Instrument helped confirm that differences exist, as was expected, and no floor or ceiling effects on the responses were observed.

Variables Measured

The main independent variables were the three professional classifications in this study (architect, constructor, design-builder). Other variables that describe the population were licenses held by the firm, their involvement in design-build, the type of work the company is involved in and the size of the firm. The type of work consists of four broad categories commonly described in the industry; residential, building construction, heavy engineering, and industrial (Pabon, 1987).

The dependent variables were the scores from each of the skill and competency questions as measured employing a seven-point Likert scale spread over the three broad areas.

Data Collection Procedures

A database of the 108 architects, 108 constructors, and 108 design-builders was developed so a letter with an individual salutation and an envelope, rather than an impersonal mailing label, could be printed. The researcher avoided utilizing mailing labels in hopes of increasing the response rate. The database also contained a tracking number for each participant which was used to code the survey instruments so confidentiality would be maintained to improve the response rate. A cover letter and envelope for the Final Survey Instrument (Appendix I) was prepared. The final version of the instrument (Appendix J) included a written tracking number placed near the top right-hand corner. The cover letter, the survey instrument, and a prepaid return envelope addressed to the co-investigator was mailed after approval was received from the Colorado State University Human Research Committee.

After two weeks, a Thank You/Reminder post card (Appendix K) was mailed to all 324 selected professionals thanking them for their response if they had returned the questionnaire or to remind them to please do so. One week later, a follow-up phone call was placed or an e-mail was sent (Appendix K) to non-respondents, utilizing the tracking list of the participants. The data was collected, tabulated, and analyzed.

Statistical Treatment

The statistical analysis of the data was performed using the Statistical Package for the Social Sciences (SPSS) at the Department of Statistics at Colorado State University. The demographic information of the participants and the findings are presented in Chapter 4. Summated scores of the architectural, construction, and business skills are reported. An analysis of variance (ANOVA) was be used to determine if there are statistically significant differences among architects, constructors, and design-builders on the three summated scores representing the three broad (architecture, construction, and general business) set of skills.

The assumptions underlying the ANOVA are (a) the observations are random and independent samples from the populations, (b) the distributions of the population from which the samples are selected are normal, and (c) the variances to distributions in the populations are equal (Hinkle, Wiersma, & Jurs, 1994). A post-hoc test was performed on those questions that were found to show a statistically significant difference among the three professions: the architect, the constructor, and the design-builder.

The individual questions relating to skills and competencies were grouped into the three classifications of skills and competencies (architecture, construction, and general business). Architecture skills questions 2, 6, 7, 10, 11, 12, 13, 15, 16, 19, 20, 24, 29, and

30 were summated and labeled SS1. Construction skills questions 3, 14, 18, 21, 22, 23, 27, 31, and 32 were summated and labeled SS2. General business skills questions 1, 4, 5, 8, 9, 17, 25, 26, and 28 were summated and labeled SS3. The ANOVAs performed on these data were used to determine if the research hypotheses were supported or unsupported.

A reliability coefficient was calculated to determine how these summated questions fit together as well as the reliability of each question. A Pearson's Correlation Coefficient was performed to test the association of company demographics and the three major skills and competencies.

Research Questions

Are there differences among architects, constructors and design-builders in requisite skills and competencies they prefer when hiring baccalaureate graduates? The research design compared the responses of the three disciplines (architects, constructors, and design-builders) to the three areas of skills and competencies (architectural skills, construction management skills, and general business skills). To restate the questions using the null hypothesis:

Question 1

H_{01}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates with "architectural" skills.

Question 2

H_{02}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates with "construction management" skills.

Question 3

H_{03}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates with "general business" skills.

The independent variables were profession type, the dependent variables were the answers to questions (on a seven-point Likert scale) randomly ordered from three areas of skills and competencies. Other demographic data, such as the primary market segment the company is involved in and the company size, were compared against the three major skills and competencies.

Summary

The study was designed to examine the differences among three building professions: architecture, construction and design-build, regarding the importance of three sets of skills and competencies of their profession: architectural skills, construction management skills, and general business skills. A questionnaire was developed based on previous surveys used by the American Institute of Constructors and the Carnegie Foundation for the Advancement of Teaching, suggestions of panel of experts, job postings in the design and building industry, and other literature. The questionnaire contained twelve demographic questions relating to the type of discipline the company was involved in and the market segment the company offered services in. The three building professions were queried on thirty-two questions relating to the three sets of skills and competencies. One hundred and eight architects, 108 constructors, and 108 design-builders were each sent a questionnaire. Analysis of the 180 returned questionnaires is described in chapter four.

CHAPTER IV

FINDINGS

Introduction

The methodology was described in Chapter III. This chapter was developed to present the findings from the responses collected from the three building professionals studied: architects, constructors, and design-builders, utilizing a mailed survey instrument (Appendix J). Two weeks after the initial questionnaire mailing, a follow-up postcard was sent to all respondents to thank them for their efforts in the study or to remind them to respond (Appendix K). The data were coded and entered into the SPSS computer program for analysis. The code book can be found in Appendix L. The results are divided into two broad sections: demographic information on the participants and statistical analysis of the results.

The demographic information follows the last page of the questionnaire and consists of five sections: (a) the type of discipline that best represents the firm, (b) the firm's involvement in design-build, (c) the industry segments the firm is engaged in, (d) the size of the firm, and (e) the respondent's interest in the results of this survey. A final open ended question allowed the participant to advance issues that could have been addressed in the survey in order to aid future studies. The responses to the open ended questions are reported by discipline: architect, constructor, and design-builder (Appendix M).

The next section, the statistical analysis portion, reports the results of the analysis of variance of the 32 questions answered utilizing a Likert scale measurement. The questions were regrouped according to the three broad skill sets being investigated: architectural skills, construction management skills, and general business skills. To test the hypotheses, summary tables of the three broad skills sets were utilized, while the ANOVA tables of each question are located in the appendices. The tables relating to architectural skills are located in Appendix N, the tables relating to construction management skills are located in Appendix O, and the tables relating to general business skills are located in Appendix P.

Response Rate

Of the 108 questionnaires mailed to each sample representing the three building professions studied, 180 of the 324 questionnaires were returned yielding a 56 percent response rate. The response rate of each profession, identified by their organizational membership, ranged from a low of 53 percent from architects to a high of 58 percent from design-builders and is reported in Table 3. This compares favorably to the Carnegie Foundation's survey of architectural alumni which obtained a response rate of 41 percent (Boyer & Mitgang, 1996).

Table 3.

Response Rate by Discipline Identified by Membership (N=180, sample size = 108 for each discipline)

Discipline	f	%	Response Rate
Architecture	57	31.7	52.8
Construction	60	33.3	55.6
Design-build	63	35.0	58.3
Total	180	100.0	

Demographic Information

Each participant was asked to indicate the discipline that best represented their firm's business. Comparisons of predetermined discipline by selection from their discipline's membership directory and respondents self identification of their firm's discipline indicated more participants identified with the traditional professions of architecture and construction management as opposed to the emerging design-build discipline. Ninety-six percent of the architects selected from the AIA membership directory maintained that the discipline that best represented their firm was architecture. Seventy-five percent of the constructors selected from the AIC membership directory maintained that the discipline that best represented their firm was construction. Sixty-seven percent of the design-builders selected from the DBIA membership directory maintained that the discipline that best represented their firm was design-build.

Two constructors and one design-builder left this category blank, but, upon reviewing other demographic variables, the discipline matching their membership was selected by the researcher. One participant from the architecture directory self-identified as working for a government agency and was placed in the "other" category in Table 4 but was kept in the pool of architects when the statistical analysis was run.

Table 4

Discipline Membership by Self Identification (N=180)

Discipline by Directory/Membership	Arch.	Constr.	Des. Bld.	Other	f	%
Architecture	55		1	1	57	31.7
Construction	1	45	5	9	60	33.3
Design-build	3	12	42	6	63	35.0
Total	59	57	48	16	180	

"Other" categories of "firm type" listed were: construction services consultant, consulting designer, electrical design-build, engineering, engineering-constructor, government agency, industry, manufacturing, office park developer, owner, owner's representative, project management, project manager, specialty (waterproofing).

The second demographic question asked the respondents to indicate the professional licenses held by their firm. Their options were any combination of architecture, construction, engineering, and other. The findings are reported in Table 5. Of the reported data, 61 percent of all participants indicated possession of a singular license while 39 percent indicated possession of multiple licenses, more than the 30 percent of the respondents identifying their firm as design-build. Five architects listed interior design as an additional license.

Table 5

Licenses Held by the Respondent's Firm

Discipline	f	%
Architecture	46	25.6
Construction	48	26.7
Engineering	5	2.8
Architecture and Construction	15	8.3
Architecture and Engineering	11	6.1
Construction and Engineering	18	10.0
Arch., Construction and Engineering	23	12.8
None	3	1.7
Left Blank	9	5.0
Other*	2	1.1
Total	180	

* Only "Other" is checked. Items listed were: (a) Electrical Contractor and (b) Real Estate License. The first six primary combinations may also have "Other" checked.

Involvement in Design-build

The next area of demographic information relates to the firm's involvement in design-build. If the respondent indicated the firm was involved in design-build, the follow-up questions sought to determine the contractual relationships used and the percent of the firm's work utilizing design-build. Table 6 indicates that over two-thirds of the respondents reported some type of involvement in design-build.

Table 6

Percentage of all Firms Reporting being Involved in Design-build (N=173)

Involvement	f	%
Yes	119	68.8
No	54	31.2

Of those firms involved in design-build, more than two-thirds indicated their firm had some level of integrated services, where design and construction management services were performed in-house. Stated another way, less than one-third indicated their involvement in design-build was only through joint ventures as shown in Table 7.

Table 7

Type of Involvement in Design-build (N=119)

Involvement	f	%
Integrated Firm	38	31.9
Joint Ventures	37	31.1
Both	44	37.0

Of those reporting involvement in design-build, almost half reported that it represents less than 20 percent of their firm's work. But, about one-sixth of the firms reported design-build represents nearly all their work as shown in Table 8.

Table 8

Percentage of the Firm's Work Performed in Design-build (N=119)

Percentage	f	%	Cumulative %
0-10	30	25.2	25.2
11-20	24	20.2	45.4
21-30	11	9.2	54.6
31-40	10	8.4	63.0
41-50	7	5.9	68.9
51-60	3	2.5	71.4
61-70	6	5.0	76.5
71-80	7	5.9	82.4
81-90	5	4.2	86.6
91-100	16	13.4	100.0

Industry Segments Firms were Involved In

The majority of respondents indicated that very little of their work involved primarily residential, heavy engineering. and industrial construction; most of the work was in the building construction segment of the market. Table 9 indicates the percentage of residential construction work with which the reporting firms were involved.

Table 9

Percentage of the Firm's Work in Residential Construction (N=176)

Percentage	f	%	Cumulative %
0-10	126	71.6	71.6
11-20	14	8.0	79.5
21-30	6	3.4	83.0
31-40	2	1.1	84.1
41-50	6	3.4	87.5
51-60	5	2.8	90.3
61-70	2	1.1	91.5
71-80	3	1.7	93.2
81-90	3	1.7	94.9
91-100	9	5.1	100.0

Table 10 indicates the percentage of building construction work with which the reporting firms were involved. This indicates that about a fourth of the reporting firms do little to no building construction work, but over half of the reporting firm's do most of their work in building construction.

Table 10

Percentage of the Firm's Work in Building Construction (N=176)

Percentage	f	%	Cumulative %
0-10	40	22.7	22.7
11-20	2	1.1	23.9
21-30	6	3.4	27.3
31-40	7	4.0	31.3
41-50	11	6.3	37.5
51-60	9	5.1	42.6
61-70	8	4.5	47.2
71-80	24	13.6	60.8
81-90	17	9.7	70.5
91-100	52	29.5	100.0

Table 11 indicates the percentage of heavy engineering work with which the reporting firms were involved. Most reporting firms have little involvement in heavy engineering work.

Table 11

Percentage of the Firm's Work in Heavy Engineering (N=179)

Percentage	f	%	Cumulative %
0-10	141	78.8	78.8
11-20	9	5.0	83.8
21-30	5	2.8	86.6
31-40	7	3.9	90.5
41-50	5	2.8	93.3
51-60	1	0.6	93.9
61-70	1	0.6	94.4
71-80	3	1.7	96.1
81-90	2	1.1	97.2
91-100	5	2.8	100.0

Table 12 indicates the percentage of industrial work with which the reporting firms were involved. Comparable to heavy engineering, most reporting firms have little involvement in industrial work.

Table 12

Percentage of the Firm's Work in Industrial (N=176)

Percentage	f	%	Cumulative %
0-10	142	80.7	80.7
11-20	10	5.7	86.4
21-30	7	4.0	90.3
31-40	3	1.7	92.0
41-50	5	2.8	94.9
51-60	0	0.0	94.9
61-70	2	1.1	96.0
71-80	2	1.1	97.2
81-90	1	0.6	97.7
91-100	4	2.3	100.0

Company Size

The next section of demographic data indicates the size of the firm by two factors: the number of employees in the firm and the annual dollar amount of construction put-in-place. This latter parameter is useful in comparing architects, whose annual revenues from fees may be 5 percent of contractor's gross revenues, and contractors. There appears to be a bimodal distribution. More than two-thirds of the respondents report their firm employs more than twenty people. Almost one-fourth are employed with a firm employing five or less employees. The data are reported in Table 13.

Table 13

Company Size in the Number of Personnel (N=176)

Personnel	f	%	Cumulative %
1-5	38	21.6	21.6
6-10	14	8.0	29.5
11-20	15	8.5	38.1
21-50	20	11.4	49.4
51-100	24	13.6	63.1
over 100	65	36.9	100.0

The company size, reported in annual volume of construction put in place, is found in Table 14. Almost two thirds of the respondents reported that their firm's volume of work, calculated by construction put in place, is under $50 million.

Table 14

Company Size in Annual Volume of Construction Put in Place (N=174)

Percentage	f	%	Cumulative %
$ 0-5 M	34	19.5	19.5
$ 5-10 M	19	10.9	30.5
$ 10-50 M	55	31.6	62.1
$ 50-100 M	20	11.5	73.6
$ 100-200 M	12	6.9	80.5
$ 200-500 M	14	8.0	88.5
over $ 500 M	20	11.5	100.0

Firms Interested in Summary of Findings

The last question on the survey instrument asked if the respondent was interested in a summary of the results of the study and is reported in Table 15.

Table 15

Percentage of Firms Interested in the Results of The Study (N=177)

Interest in Summary of Results	f	%
Yes	133	75.1
No	44	24.9

Findings

The findings from the 32 questions are reported in Table 16. The table contains all 32 questions in the order they appeared on the questionnaire. The mean scores reported by each group of professionals are listed. The score is based on a seven point Likert scale arranged with values from one being not important to a value of 7 as being extremely important. The mean score of all questions answered by the three groups of professionals and the standard deviations are also reported.

Table 16

Means and Standard Deviations of all Skills Questions Between Groups

	Question	Architects (A) Mean	Constructors (C) Mean	Design Builders (DB) Mean	All Professions Mean	Std. Dev.	Valid N
1	Ability to create, maintain and enhance effective working relationships:	6.17	6.23	6.22	6.21	0.99	179
2	Ability to write/interpret specifications:	4.78	5.30	5.30	5.12	1.36	177
3	Ability to do building layout on the site:	4.15	4.00	4.09	4.08	1.65	178
4	Adeptness as an entrepreneur:	3.30	4.20	4.85	4.10	1.52	179
5	Ability to use word-processors and spreadsheets routinely:	4.88	5.51	5.61	5.33	1.27	179
6	Ability to problem solve:	6.64	6.54	6.39	6.53	0.65	180
7	Ability in graphic/hand communication:	5.95	3.98	4.67	4.86	1.50	180
8	Effectiveness in marketing and customer relations:	4.52	4.95	5.63	5.01	1.44	179
9	Effectiveness in written communication:	5.70	5.85	5.96	5.83	0.94	180

Remaining data have been continued on the following page

Table 16 (continued) Means and Standard Deviations of all Skills Questions Between Groups

	Question	Architects (A) Mean	Constructors (C) Mean	Design Builders (DB) Mean	All Professions Mean	All Professions Std. Dev.	All Professions Valid N
10	Creative ability:	6.08	5.18	5.63	5.62	1.08	180
11	Knowledge of use of materials and methods of construction:	5.66	5.60	5.54	5.60	1.09	180
12	Knowledge of local codes (building, planning):	4.61	4.37	4.31	4.43	1.47	180
13	Ability to understand integration of systems:	5.28	4.92	5.20	5.13	1.19	179
14	Ability to perform value engineering or life cycle costs of a project:	3.69	4.62	5.19	4.47	1.49	180
15	Knowledge of Model Codes (BOCA, SBC, UBC):	4.46	3.97	4.35	4.25	1.30	180
16	Ability to write/interpret contracts:	3.49	4.94	5.20	4.53	1.66	178
17	Ability to generate business computer presentation using Powerpoint:	3.48	3.59	4.30	3.76	1.55	178
18	Knowledge of safety laws (such as OSHA):	3.77	4.86	4.72	4.44	1.43	178
19	Knowledge of theory of architectural design and architectural history:	4.90	2.91	3.11	3.65	1.65	179
20	Ability to graphically solve problems:	6.02	4.94	4.85	5.28	1.19	177
21	Ability to develop a simple schedule (such as a bar chart) for a project:	4.93	6.06	5.69	5.57	1.36	178
22	Ability to use computer software to generate sophisticated schedules (such as Primavera):	3.36	5.16	4.93	4.47	1.64	179
23	Ability to estimate cost of structures:	3.82	5.50	5.44	4.91	1.53	179

Remaining data have been continued on the following page

Table 16 (continued) Means and Standard Deviations of all Skills Questions Between Groups

	Question	Architects (A) Mean	Constructors (C) Mean	Design Builders (DB) Mean	All Professions Mean	All Professions Std. Dev.	All Professions Valid N
24	Ability to think spatially, in three dimensions:	6.52	5.55	5.65	5.91	1.11	179
25	Effectiveness in verbal communication:	6.20	6.30	6.37	6.29	0.80	178
26	Ability to use the Internet and e-mail routinely:	4.61	4.44	5.07	4.69	1.47	179
27	Ability to use estimating software programs (such as Timberline):	3.25	4.94	4.93	4.36	1.61	179
28	Knowledge of accounting and finance:	3.20	4.41	4.33	3.97	1.46	179
29	Knowledge of structural theory:	5.10	4.31	4.22	4.55	1.40	179
30	Ability to use CAD programs routinely (such as AutoCAD):	5.95	3.61	4.22	4.59	1.84	179
31	Ability to plan construction project execution: (scheduling, resource leveling, site utilization)	3.74	5.86	5.76	5.11	1.61	179
32	Ability to monitor project costs:	4.26	5.94	6.06	5.40	1.47	179

The findings from the thirty-two questions relating to the three major questions being studied are arranged in the order of the research questions. The skills relating to architecture are followed by the skills relating to construction and, finally, the skills relating to general business. Each summary table is arranged, left to right, with the question number (Q), restatement of the question as it appeared on the questionnaire, and the means reported by the three types of professionals (architects, constructors and design-builders). The differences among the means were analyzed to test the statistical significance of the differences. An ANOVA was performed on the data and the calculated F ratio, with asterisks indicating the level of significance, is listed next. The asterisks indicate the level of significance as follows: *$p < .05$, **$p < .01$, ***$p < .001$. An interpretation of the significance, if found, was noted in the last column. The ANOVA tables for each question can be found in Appendices N thorough P arranged by skill types (Appendix N, architecture; Appendix O, construction; Appendix P, general business). The ANOVA tables indicate the source of variation between the groups and within the groups and the overall F statistic. Only those questions that were shown to have a significant difference among the three professions had a post hoc, multiple range test, performed. The Multiple Range Test table indicates the means among the three professions and an asterisk, or series of asterisks, indicates which groups demonstrated a difference that was statistically significant.

Results of Questions Relating to Architectural Skills

Individual Question Means and F ratio

The F ratios for each question relating to architectural skills are summarized in Table 17. Significance levels are indicated by asterisks. The relationship of the significance among the three groups (professions) is indicated in the far right column. The ANOVA table for each question relating to architectural skills can be found in Appendix N. Where statistical differences between pairs were found, a Multiple Range Test Table followed the ANOVA table to indicate which groups differ as designated by an asterisk. The mean is reported so the order of the relationship can be understood. Eight of the fourteen questions relating to architectural skills indicated a significant difference among the groups. In four of those eight questions (19, 20, 24, and 29), architects rated those skills greater than constructors and design-builders. In three of those questions (7, 10, and 30), architects rated those skills greater than design-builders who rated those skills greater than constructors.

Table 17

Means and Summary Results of Analysis of Variance for all Questions Related to Architectural Skills

Q		Arch.	Constr.	Des. Bldr.	F Ratio	Significance
2	Ability to write/interpret specifications:	4.78	5.30	5.30	2.92	
6	Ability to problem solve:	6.64	6.54	6.39	2.19	
7	Ability in graphic/hand communication:	5.95	3.98	4.67	39.34***	A > DB > C
10	Creative ability:	6.08	5.18	5.63	12.13*	A > DB > C
11	Knowledge of use of materials and methods of construction:	5.66	5.60	5.54	0.17	
12	Knowledge of local codes (building, planning):	4.61	4.37	4.31	0.66	
13	Ability to understand integration of systems:	5.28	4.92	5.20	1.57	
15	Knowledge of Model Codes (BOCA, SBC, UBC):	4.46	3.97	4.35	2.50	
16	Ability to write/interpret contracts:	3.48	4.94	5.20	22.78***	DB and C > A
19	Knowledge of theory of architectural design and architectural history:	4.90	2.91	3.11	37.94***	A > DB and C
20	Ability to graphically solve problems:	6.02	4.94	4.85	22.18***	A > DB and C
24	Ability to think spatially, in three dimensions:	6.52	5.55	5.65	16.70***	A > DB and C
29	Knowledge of structural theory:	5.10	4.31	4.22	7.57***	A > DB and C
30	Ability to use CAD programs routinely (such as AutoCAD):	5.95	3.61	4.22	38.14***	A > DB > C

* $p < .05$, *** $p < .001$

Summated Question Means

Table 18 indicates the summated means and standard deviations of all questions relating to architectural skills as reported by architects, constructors, and design-builders. Architects rated these skills highest (M = 5.54), with the smallest standard deviation among the groups (SD = 0.54). Design-builders had the second highest mean (M = 4.88) and the widest standard deviation (SD = 0.80). Constructors had the lowest mean (M = 4.71, SD = 0.74).

Table 18

Mean Scores for Summated Architecture Skills (SS1): Questions 2, 6, 7, 10, 11, 12, 13, 15, 16, 19, 20, 24, 29, and 30

Discipline	N	Mean*	Standard Deviation
Architects	61	5.54	0.54
Constructors	65	4.71	0.74
Design-builders	54	4.88	0.80
Total	180	5.04	0.78

* Based on a 7 point Likert Scale ranging from 1 being not important to 7 being extremely important.

Analysis of Variance

An analysis of variance was performed on the summated architecture skills questions and is reported in Table 19. The data indicate there is a significant difference among the groups when reporting the need for these skills.

Table 19

Analysis of Variance for Summated Architecture Skills (SS1): Questions 2, 6, 7, 10, 11, 12, 13, 15, 16, 19, 20, 24, 29, and 30

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	23.52	11.76	24.01
Within Groups	177	86.69	0.49	
Total	179	110.21		

$p < .001$

Multiple Range Test

After the one-way analysis of variance revealed significant differences among the three groups, $F(2,177)=24.01$, $p<.001$, comparisons of the three groups were made using the Duncan Multiple Range Test. The test indicated that architects were significantly different from constructors and design-builders and is reported in Table 20. Architects rated these scores higher than both constructors and design-builders. These was no statistically significant difference between constructors and design-builders.

Table 20

Multiple Range Test for Summated Architecture Skills (SS1):

Mean	Profession	Architects	Constructors	Design-builders
5.54	Architects		*	*
4.71	Constructors			
4.88	Design-builders			

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups
$p < .05$

Reliability Analysis

A reliability analysis was performed on the fourteen questions relating to architectural skills. Table 21 indicates the reliability coefficient for each question. Question 16 relating to the ability to write and interpret contracts had a coefficient of 0.09. The reason this was low may be due to the dual nature of the question (Ability to write/interpret contracts). Architects may value the ability to write a contract and constructors would value the ability to interpret contract. Newly hired architecture graduates would seldom prepare contracts and newly hired constructors would need to know the scope of the agreement in the contract. The alpha coefficient for the 14 architectural questions was 0.82 indicating the grouping of questions was rational.

Table 21

Reliability Analysis of Summated Architecture Skills (SS1): Questions 2, 6, 7, 10, 11, 12, 13, 15, 16, 19, 20, 24, 29, and 30 (N=171)

Q	Question	Corrected Item-Total Correlation
2	Ability to write/interpret specifications:	0.32
6	Ability to problem solve:	0.32
7	Ability in graphic/hand communication:	0.45
10	Creative ability:	0.44
11	Knowledge of use of materials and methods of construction:	0.40
12	Knowledge of local codes (building, planning):	0.61
13	Ability to understand integration of systems:	0.62
15	Knowledge of Model Codes (BOCA, SBC, UBC):	0.61
16	Ability to write/interpret contracts:	0.09
19	Knowledge of theory of architectural design and architectural history:	0.53
20	Ability to graphically solve problems:	0.57
24	Ability to think spatially, in three dimensions:	0.53
29	Knowledge of structural theory:	0.57
30	Ability to use CAD programs routinely (such as AutoCAD):	0.46
	Alpha	0.82

Appendix M contains a summary of the responses to the open-ended question (Are there other skills and competencies you believe should be included in this questionnaire?) contained at the end of the questionnaire. The twelve responding architects added few thoughts on technical skills but often mentioned character traits such as a strong work ethic, reliability, and a collaborative attitude.

Hypothesis Question No. 1 Tested

H_{O1}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "architectural" skills.

H_{A1}: There are statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "architectural" skills.

The value of the F statistic found in Table 19 was statistically significant at the .001 alpha level. The null hypothesis was rejected and the alternate hypothesis was accepted. The results indicate there are differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "architectural" skills. Architects rated these scores higher than both constructors and design-builders. These was no statistically significant difference between constructors and design-builders as reported in Table 20, the Multiple Range Test for Summated Architecture Skills (SS1).

Results of Questions Relating to Construction Skills

Individual Question Means and F ratio

The F ratios for each question relating to construction skills are summarized in Table 22. Significance levels are indicated by asterisks. The relationship of the significance among the three groups (professions) is indicated in the far right column. The ANOVA table for each question relating to construction skills can be found in Appendix O. Where statistical differences between pairs were found, a Multiple Range Test Table followed the ANOVA table to indicate which groups differ as designated by an asterisk. The mean is reported so the order of the relationship can be understood. Eight of the nine questions relating to construction skills indicated a significant difference among the groups. In seven of those questions, (18, 21, 22, 23, 27, 31, and 32), constructors and design-builders rated those skills greater than architects. Only one question, question 14, the "ability to perform value engineering or life cycle costs of a project," did design-builders rate higher than both the constructors and architects.

Table 22

Means and Summary Results of Analysis of Variance for all Questions Related to Construction Skills

Q		Arch.	Constr.	Des. Bldr.	F Ratio	Significance
3	Ability to do building layout on the site:	4.15	4.00	4.09	0.13	
14	Ability to perform value engineering or life cycle costs of a project:	3.69	4.62	5.19	17.84***	DB > C > A
18	Knowledge of safety laws (such as OSHA):	3.77	4.85	4.72	11.69***	C and DB > A
21	Ability to develop a simple schedule (such as a bar chart) for a project:	4.93	6.06	5.69	12.45***	C and DB > A
22	Ability to use computer software to generate sophisticated schedules (such as Primavera):	3.36	5.16	4.93	28.13***	C and DB > A
23	Ability to estimate cost of structures:	3.82	5.50	5.44	31.66***	DB and C> A
27	Ability to use estimating software programs (such as Timberline):	3.25	4.94	4.93	29.02***	DB and C> A
31	Ability to plan construction project execution: (scheduling, resource leveling, site utilization)	3.74	5.86	5.76	52.78***	C and DB > A
32	Ability to monitor project costs:	4.26	5.94	6.06	40.16***	DB and C > A

* $p < .05$, ** $p < .01$, *** $p < .001$

Summated Question Means

Table 23 reports the summated means and standard deviations of all questions relating to construction skills as reported by architects, constructors, and design-builders. Constructors rated these skill the highest (M = 5.36) and had the lowest standard deviation (SD = 0.84). Design-builders rated these skills very close to constructors (M = 5.34) but, with a wider standard deviation (SD = 0.91). Architects rated these skills the lowest (M = 3.85) and had the highest standard deviation among the groups (SD = 1.11).

Table 23

Mean Scores for Summated Construction Skills (SS2): Questions 3, 14, 18, 21, 22, 23, 27, 31, and 32

Discipline	Count	Mean*	Standard Deviation
Architects	61	3.85	1.11
Constructors	65	5.36	0.84
Design-builders	54	5.34	0.91
Total	180	4.84	1.19

* Based on a 7 point Likert Scale ranging from 1 being not important to 7 being extremely important.

Analysis of Variance

An analysis of variance was performed on the summated construction skills and is reported in Table 24. The data indicate there is a significant difference among the groups when reporting the need for these skills.

Table 24

Analysis of Variance for Summated Construction Skills (SS2): Questions 3, 14, 18, 21, 22, 23, 27, 31, and 32

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	91.1	45.55	49.39
Within Groups	177	163.24	0.92	
Total	179	254.34		

$p < .001$

Multiple Range Test

After the one-way analysis of variance revealed significant differences among the three groups, $F(2,177)=49.39$, $p<.001$ comparisons of the three groups were made using the Duncan Multiple Range Test. The test indicated that constructors and design-builders were significantly different from architects and is reported in Table 25.

Table 25

Multiple Range Test for Summated Construction Skills (SS2):

Mean	Profession	Architects	Constructors	Design-builders
3.85	Architects			
5.36	Constructors	*		
5.34	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups
$p < .05$

Reliability Analysis

A reliability analysis was performed on the nine questions relating to construction skills. Table 26 indicates the reliability coefficient for each question. Question 3 relating to the ability to do building layout had a coefficient of 0.15. The reason this is low may be due to inconsistent interpretations of the meaning of the question (Ability to do building layout on the site). The alpha coefficient for the 9 construction questions was 0.88 indicating the grouping of the questions was rational.

Table 26

Reliability Analysis of Summated Construction Skills (SS2):
Questions 3, 14, 18, 21, 22, 23, 27, 31, and 32 (N=175)

Q	Question	Corrected Item-Total Correlation
3	Ability to do building layout on the site:	0.15
14	Ability to perform value engineering or life cycle costs of a project:	0.61
18	Knowledge of safety laws (such as OSHA):	0.63
21	Ability to develop a simple schedule (such as a bar chart) for a project:	0.57
22	Ability to use computer software to generate sophisticated schedules (such as Primavera):	0.77
23	Ability to estimate cost of structures:	0.77
27	Ability to use estimating software programs (such as Timberline):	0.69
31	Ability to plan construction project execution: (scheduling, resource leveling, site utilization)	0.78
32	Ability to monitor project costs:	0.78
	Alpha	0.88

Appendix M contains a summary of the responses to the open-ended question (Are there other skills and competencies you believe should be included in this questionnaire?) contained at the end of the questionnaire. The thirteen responding constructors, just like the responding architects, added few thoughts on technical skills but often mentioned character traits such as integrity, leadership, a good work ethic, and people skills.

<u>Hypotheses No. 2 Tested</u>

H_{O2}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "construction management" skills.

H_{A2}: There are statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "construction management" skills.

The value of the F statistic found in Table 24 was statistically significant at the .001 alpha level. The null hypothesis was rejected and the alternate hypothesis was accepted. The results indicate there are differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "construction management" skills. Constructors and design-builders rated these scores higher than Architects. These was no statistically significant difference between constructors and design-builders as reported in Table 25, the Multiple Range Test for Summated Construction Skills (SS2).

Results of Questions Relating to General Business Skills

Individual Question Means and F ratio

The F ratios for each question relating to general business skills are summarized in Table 27. Significance levels are indicated by asterisks. The relationship of the significance among the three groups (professions) is indicated in the far right column. The ANOVA table for each question relating to general business skills can be found in Appendix P. Where statistical differences between pairs were found, a Multiple Range Test Table follows the ANOVA table to indicate which groups differ as designated by an asterisk. The mean is reported so the order of the relationship can be understood. Five of the nine questions relating to general business skills indicated a significant difference among the groups. In three of those questions (4, 8, and 17), design-builders rated those skills greater than both constructors and architects. The highest means, on average, can be found in question 25 (Effectiveness in verbal communication). Table 16 reports this to also have a low standard deviation. There is not a significant difference among the groups, they all deem it important.

Table 27

Means and Summary Results of Analysis of Variance for all Questions Related to General Business Skills

Q		Arch.	Constr.	Des. Bldr.	F Ratio	Significance
1	Ability to create, maintain and enhance effective working relationships:	6.17	6.23	6.22	0.07	
4	Adeptness as an entrepreneur:	3.30	4.20	4.85	17.91***	DB > C > A
5	Ability to use word-processors and spreadsheets routinely:	4.88	5.51	5.61	5.98**	DB and C > A
8	Effectiveness in marketing and customer relations:	4.52	4.95	5.63	9.28***	DB > A and C
9	Effectiveness in written communication:	5.70	5.85	5.96	1.10	
17	Ability to generate business computer presentation using Powerpoint:	3.48	3.58	4.30	4.84**	DB > A and C
25	Effectiveness in verbal communication:	6.20	6.30	6.37	0.64	
26	Ability to use the Internet and e-mail routinely:	4.61	4.44	5.07	2.95	DB > C F Prob. = .0550
28	Knowledge of accounting and finance:	3.20	4.41	4.33	15.10***	DB and C > A

$* p < .05$. $** p < .01$. $*** p < .001$

Summated Questions Means

Table 28 indicates the summated means and standard deviations of all questions relating to general business skills as reported by architects, constructors, and design-builders. Design-builders rated these skills highest (M = 5.37) with a standard deviation of 0.76. Constructors followed design-builders with the second highest mean (M = 5.37), however, had the lowest standard deviation (SD = 0.68). Architects rated the skills the lowest (M = 4.67), however, had the highest standard deviation (SD = 0.82).

Table 28

Mean Scores for Summated General Business Skills (SS3): Questions 1, 4, 5, 8, 9, 17, 25, 26, and 28

Discipline	Count	Mean*	Standard Deviation
Architects	61	4.67	0.82
Constructors	65	5.06	0.68
Design-builders	54	5.37	0.76
Total	180	5.02	0.80

* Based on a 7 point Likert Scale ranging from 1 being not important to 7 being extremely important.

Analysis of Variance

An analysis of variance was performed on the summated general business skills questions and is reported in Table 29. The data indicate there is a significant difference among the groups when reporting the need for these skills.

Table 29

Analysis of Variance for Summated General Business Skills (SS3): Questions 1, 4, 5, 8, 9, 17, 25, 26, and 28

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	14.27	7.13	12.55
Within Groups	177	100.65	0.57	
Total	179	114.92		

$p < .001$

Multiple Range Test

After the one-way analysis of variance revealed significant differences among the three groups, $F(2,177)=12.55$, $p<.001$ comparisons of the three groups were made using the Duncan Multiple Range Test. The test indicated that design-builders were significantly different from constructors and constructors were significantly different from architects and is reported in Table 30.

Table 30

Multiple Range Test for Summated General Business Skills (SS3):

Mean	Profession	Architects	Constructors	Design-builders
4.67	Architects			
5.06	Constructors	*		
5.37	Design-builders	*	*	

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups
$p < .05$

Reliability Analysis

A reliability analysis was performed on the nine questions relating to general business skills and is reported in Table 31. The alpha coefficient for the nine general business questions was 0.80 indicating the grouping of the questions was rational.

Table 31

Reliability Analysis of Summated General Business Skills (SS3): Questions 1, 4, 5, 8, 9, 17, 25, 26, and 28 (N=175)

Q #	Question	Corrected Item-Total Correlation
1	Ability to create, maintain and enhance effective working relationships:	0.31
4	Adeptness as an entrepreneur:	0.55
5	Ability to use word-processors and spreadsheets routinely:	0.51
8	Effectiveness in marketing and customer relations:	0.53
9	Effectiveness in written communication:	0.54
17	Ability to generate business computer presentation using Powerpoint:	0.57
25	Effectiveness in verbal communication:	0.46
26	Ability to use the Internet and e-mail routinely:	0.45
28	Knowledge of accounting and finance:	0.56
	Alpha	0.80

Appendix M contains a summary of the responses to the open-ended question (Are there other skills and competencies you believe should be included in this questionnaire?) contained at the end of the questionnaire. The responding architects, constructors, and design-builders added few thoughts on technical skills but often recognized soft skills such as character, integrity, leadership, a positive attitude, and people skills as being important.

Hypotheses No. 3 Tested

H_{O3}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "general business" skills.

H_{A3}: There are statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "general business" skills.

The value of the F statistic found in Table 29 was statistically significant at the .001 alpha level. The null hypothesis was rejected and the alternate hypothesis was accepted. The results indicate there are differences among architects, constructors, and design-builders in preferring baccalaureate graduates who possess strong "general business" skills. Design-builders rated these skills higher than both constructors and architects. Constructors rated these score higher than architects as reported in Table 30.

Summary

This chapter has presented the statistical analyses of the data collected in this study. There were 32 questions studied individually and collectively utilizing three broad summated scores of the questions.

Architects rate those architectural skills, collectively listed in Table 17, statistically significantly higher than both constructors and design-builders. Constructors and design-builders rate those construction skills, collectively listed in Table 22, statistically significantly higher than architects. Design-builders rate those general business skills, collectively listed in Table 27, statistically significantly higher than constructors. Constructors rate those business skills statistically significantly higher than architects.

The responses to some of the questions were shown to have no significant difference among the three professions studied, but the skills were rated very high by all the professions. These were, question 1: ability to create, maintain and enhance effective working relationships (M = 6.21, SD = 0.99); question 2: ability to problem solve (M = 6.53, SD = 0.65); and question 25: effectiveness in verbal communication (M = 6.29, SD = 0.80). The conclusions and recommendations of the research study are presented in Chapter 5 of the study.

CHAPTER V

DISCUSSION

Introduction

The four previous chapters have described the problem and offered a series of research questions, reviewed the relevant available literature, described the research design and the research methodology, and reported the results of the statistical analysis used to address the research questions. This chapter summarizes the study, discusses the results and makes inferences based on those results, provides recommendations for additional research, and closes with some final comments.

The reemerging field of design-build, harking from Renaissance days of the "master builders," requires a blend of core skills from the disciplines of architecture and construction. The popularity of this alternative delivery system has often led to contractual relationships between designers (architects and engineers) and builders (constructors). Education in the disciplines of architecture and construction has been refined over the years by observations and studies of their respective practitioners and may still consist of ingredients of elitism. The Boyer Commission Report (1998) challenged the rigidity among university departments and resistance to removing barriers to interdisciplinary education. Beyond the integration of design and construction management, Harrigan and Neel (1996) suggested that the way to improve client satisfaction and to expand services would be direct participation in the client's endeavors. Those in industry that have recognized this have pursued alternative delivery systems.

Some of these delivery systems go beyond design-build and include design-build-lease and design-build-lease-to-own, also called build-own-transfer or BOT. Specializations in real estate, marketing, and finance then become significant. The master builder must understand the client's business. Could a renaissance architect properly serve the client, and the client's constituents, without knowledge of the client's business? Can today's client be served by a mere contractual relationship between an architect and constructor or will there be a call for the return of the "master builder?"

The purpose of the study was to determine what skills design-builders find important in graduates they would hire from architecture and construction programs. Based on previous studies in the fields of architecture and construction, which were used to develop programs in higher education for their disciplines, a hybrid questionnaire was developed by this researcher and sent to practitioners in the fields of architecture, construction, and design-build. The primary question in this study was: are there differences among architects, constructors, and design-builders in requisite skills and competencies they prefer when hiring baccalaureate graduates? The major hypothesis in the study was that there are statistically significant differences among the three disciplines in the requisite skills of baccalaureate graduates sought by architects, constructors, and design-builders. It was believed that previous studies indicating requisite skills of architects and constructors would be verified, and that new information on requisite skills of design-builders would be observed.

The procedure used a questionnaire consisting of thirty-two questions utilizing a seven-point Likert scale. In addition to a few demographic questions related to the nature and size of the company, open ended questions were recorded. The data were analyzed using the SPSS statistical computer program and were summarized in Chapter 4.

Discussion of Findings

The major findings were that there were statistically significant differences in requisite skills sought by architects, constructors, and design-builders. Design-builders appeared to have more in common with constructors than they did with architects. However, what sets design-builders apart from both constructors and architects were skills relating to marketing and entrepreneuring. Specific differences are discussed below.

Differences Among the Three Disciplines Relating to Architectural Skills

Through analyses of variances performed on the summated questions pertaining to architectural skills (SS1) as reported in Table 19, differences were shown to exist among the three professions relating to architectural skills.

Conclusion to Hypothesis for Question 1

Restating the hypothesis to question number one:

H_{01}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates with "architectural" skills.

The null hypothesis has been rejected.

Table 20, the post hoc test, reports that architects rated architectural skills statistically significantly higher than constructors and design-builders.

Of the mean scores for the fourteen questions relating to architectural skills (questions 2, 6, 7, 10, 11, 12, 13, 15, 16, 19, 20, 24, 29, and 30), question 16 was found to be unreliable, and there were significant differences found in seven of the remaining thirteen questions. Figure 3 graphs the mean scores of the questions relating to architectural skills where statistically significant differences were found among architects, constructors, and design-builders.

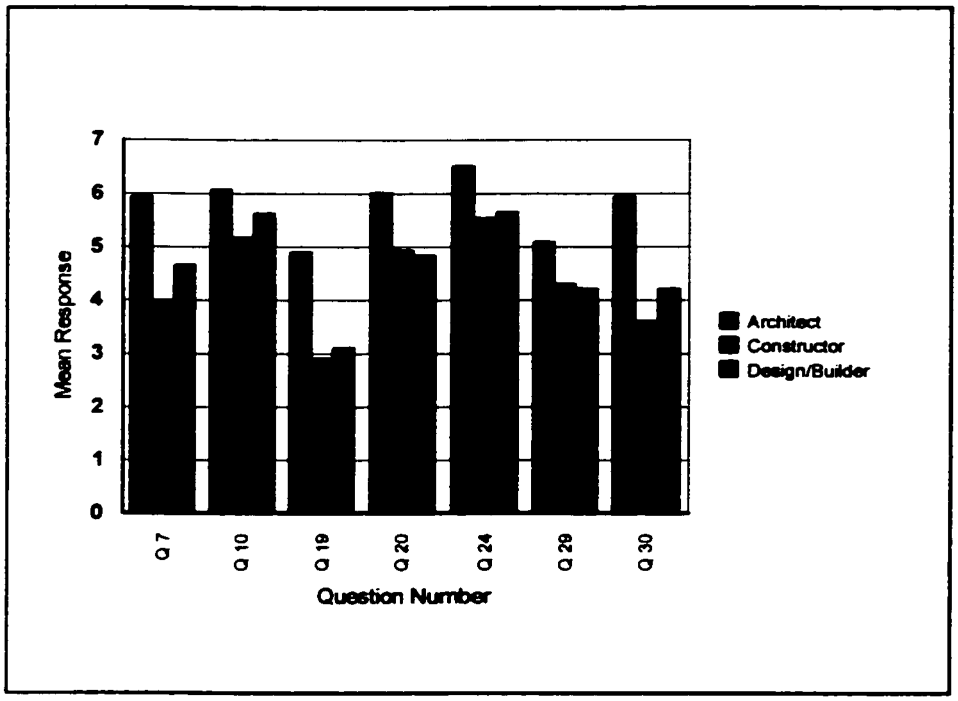

Figure 3. Mean Scores of the Questions Associated with Architectural Skills

Of all 32 questions, question 6, the ability to problem solve, received the highest score and had the lowest standard deviation (M = 6.53, SD = 0.65) among the three professions. Architects rated this skill the highest (M = 6.64); it was the highest rated score of all questions reported by all three professions. Ninety-six percent of administrators and alumni of architecture programs say their schools' graduates are "well prepared" as problem solvers; eighty-two percent of the faculty agree (Boyer & Mitgang, 1996). This quality is "among the most prized in new employees" (p. 6) sought by architectural firms.

Notice how the mean scores by architects differ from the nearly matched scores of the constructors and design-builders. Over half of the seven questions (questions 19, 20, 24, and 29) indicate that constructors and design-builders held similar views regarding the importance of these architectural skills.

Questions 7 and 30, the abilities in graphic communication and use of CAD, were scored high by architects and lower by both constructors and design-builders. This may be explained because the architect's primary instrument of service are the drawings.

Question 10, regarding creative ability, was scored high by architects (M = 6.08), followed by design-builders (M = 5.63) and then by Constructors (M = 5.18). Some constructors demonstrate a "just give me the plans and I'll build it" philosophy and regard creativity less important than "getting the job done;" which is more goal oriented than process oriented.

While there were no statistically significant differences among the three professions regarding question 13, the ability to understand integration of systems, some respondent expressed their thoughts. Issues regarding the historic separation of the design phase from the building phase impairing constructability, as discussed by Mulligan and Knutson (1999), were found in a response to the open ended question by two of the design-builders (Appendix M). Design-builders #1 and #2 expressed a desire for graduates possessing some constructability knowledge.

The largest gap existed with question 19 regarding architectural design and architectural history. The architect's mean score was the highest (M = 4.90) while the design-builder's score (M = 3.11) was slightly higher than the constructors (M = 2.91). This knowledge is a core competency and is often misunderstood by others. This manifests itself in designs by architects that are not understood, or appreciated, by the public; sometimes not even by peer architects.

The ability to graphically solve problems, question 20, was rated highest by architects (M = 6.02), followed by constructors (M = 4.94) and design-builders (M = 4.85) respectively. Architects more often solve spatial problems graphically in lieu of utilizing calculations. They often draw even conceptual ideas to a scale. When given problems that can be solved algebraically by mathematicians, architects often opt for graph paper.

Question 24, the ability to think spatially, in three dimensions, was found to have a mean score among all participants of 5.91 as reported in Table 16. This high score may be explained by the fact that all three professions operate in a three dimensional environment compared to, for example, computer programmers who are often more linear in their work.

Knowledge of structural theory, question 29, was, like question 19, architectural design and history, rated high by architects (M = 5.10) and lower by constructors (M = 4.31) and design-builders (M = 4.22). The reason constructors and design-builders rated these scores higher compared to question 19 is the liability involved in the failure to understand and execute structural detailing. Field changes in structural detailing have caused the failure of portions of buildings resulting in the loss of life. These concerns are similar to construction safety concerns (Question 18).

Differences Among the Three Disciplines Relating to Construction Skills

Through analyses of variances performed on the summated questions pertaining to construction skills (SS2) as reported in Table 24, differences were shown to exist among the three professions relating to construction skills.

Conclusion to the Hypothesis for Question 2

Restating the hypothesis to question number two:

> H_{02}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates with "construction management" skills.

The null hypothesis has been rejected.

Table 25, the post hoc test, reports that constructors and design-builders rated construction skills statistically significantly higher than architects.

Of the mean scores for the nine questions relating to construction skills (questions 3, 14, 18, 21, 22, 23, 27, 31, and 32), question 3 was found to be unreliable, and there were significant differences found in all of remaining eight questions. Figure 4 graphs the mean scores of the questions relating to construction skills where statistically significant differences were found among architects, constructors, and design-builders.

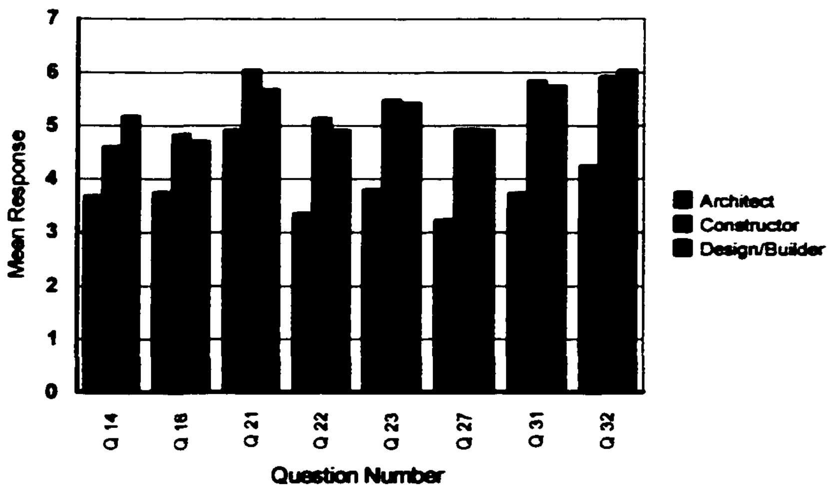

Figure 4. Mean Scores of the Questions Associated with Construction Skills

Seven of the eight questions (questions 18, 21, 22, 23, 27, 31, and 32) indicate that constructors and design-builders held similar views regarding the importance of these construction skills.

Question 14, the ability to perform value engineering or life cycle costing for a project, was rated higher by design-builders (M = 5.19) than constructors (M = 4.62) and architects (M = 3.69). Two trends discussed by Sullivan (1997) that attract owners to design-build were fast-tracked, low-cost building projects, and a lack of financial and professional capital. Design-builders recognize the strategic importance of the flexibility and speed of alternate delivery systems. The approach is meant to enhance value and not to merely reduce costs. Design-builders may be more in touch with owners' needs as evidenced by the increasing use of design-build and design-builders' appreciation of entrepreneuring as posed in question 4, adeptness as an entrepreneur.

Knowledge of safety laws, question 18, in an important job site function of the constructor. Architects often distance themselves from the issue of worker safety for reasons of liability, but may react to safety violations that may be deemed criminally negligent to otherwise not report. Constructors rated this slightly higher (M = 4.85) than design-builders (M = 4.72) who rated it higher than architects (M = 3.77).

Only one question, question 21, the ability to develop a simple schedule such as a bar chart, was rated somewhat high by architects (M = 4.93). This reflects its use in their contract administration responsibilities. This is still lower that the means reported by constructors (M = 6.06) and by design-builders (M =5.69).

Question 22, computer scheduling; question 23, cost estimating; question 27, computer estimating; question 31 project execution; and question 32, monitoring project costs, are historically core competencies of constructors. Design-builders held similar view to constructors compared to architects regarding these skills. Question 32, regarding the monitoring project costs, was rated slightly higher by design-builders (M = 6.06) as compared to constructors (M = 5.94). Though not statistically significant, this may be explained by the contracts that place design-builders at risk for both design and construction. The earlier cost estimates are discovered to be over budget, the earlier redesign or value engineering can be performed in order to bring the project back in budget.

Differences Among the Three Disciplines Relating to General Business Skills

Through analyses of variances performed on the summated questions pertaining to general business skills (SS3) as reported in Table 29, differences were shown to exist among the three professions relating to general business skills.

Conclusion to the Hypothesis for Question 3

Restating the hypothesis to question number three:

H_{03}: There are no statistically significant differences among architects, constructors, and design-builders in preferring baccalaureate graduates with "general business" skills.

The null hypothesis has been rejected.

Table 30, the post hoc test, reports that design-builders rated general business skills statistically significantly higher than constructors and constructors rated general business skills statistically significantly higher than architects.

Of the mean scores for the nine questions relating to general business skills (questions 1, 4, 5, 8, 9, 17, 25, 26, and 28), none were found to be unreliable, and there were significant differences found in six of the nine questions. Figure 5 graphs the mean scores of the questions relating to general business where statistically significant differences were found among architects, constructors, and design-builders.

The skill listed in question 1, the ability to create, maintain and enhance effective working relationships, was rated high by the three groups (M = 6.21, SD = 0.99) and was often cited in the literature as well as in the responses to the open ended questions as reported in Appendix M. Beder (1999) cited a study critical of deficiencies in educational curricula furnishing graduates lacking in social understanding and human interaction skills. Boyer and Mitgang (1996) report that only 46 percent of architecture school alumni "thought their alma maters had done a good job fostering the ability 'to work cooperatively in interdisciplinary teams.' " (p. 110).

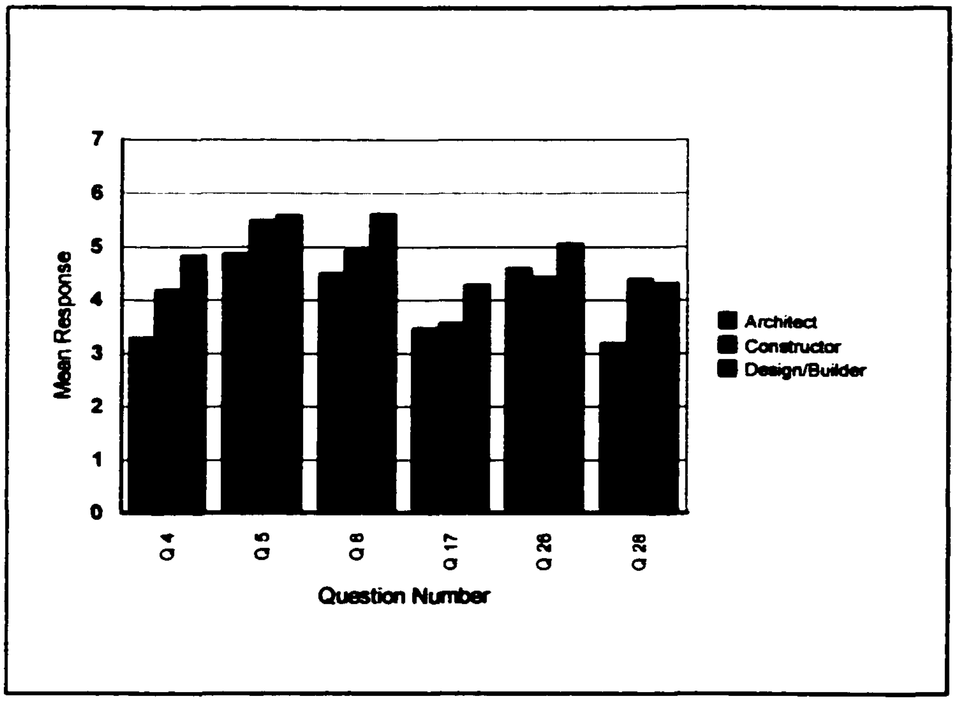

Figure 5. Mean Scores of the Questions Associated with General Business Skills

The results were mixed when comparing these six questions (questions 4, 5, 8, 17, 26, and 28) regarding the importance of general business skills among architects, constructors, and design-builders. Design-builders rated the skill in question number four (adeptness as an entrepreneur) higher (M = 4.85) than that expressed by constructors (M = 4.20), who in turn rated the skill higher than that expressed by architects (M = 3.30), (Table 16). This low score by architects reflects Harrigan and Neel's (1996) counter argument that architects should, as all good entrepreneurs, understand their clients' needs. This goes beyond the spatial and programming requirements architects are trained to perform. They cite architect Charles Luckman as their first example in their book.

Luckman, author of "Twice in a Lifetime," was trained as an architect. By age 37, he became president of Lever Brothers and was labeled "Boy Wonder" on a 1937 cover of Time magazine. During a lecture to architecture students in 1982, he was quoted to say "Learn to listen to your clients...it's a shocking thought, but your client was smart enough to make enough money to hire you and to afford to build a building. Listen. You may just possibly learn." (Lota, 1999).

Questions 5, the ability to use word-processors and spreadsheets routinely, was rated highest by design-builders (M = 5.61), then by constructors (M = 5.51), followed by architects (M = 4.88). Architects may have rated this lower because their primary instrument of service are the drawings; lines draw by hand or by CAD (Questions 7, 20, 30: Table 16), not responding to proposals and RFI's (requests for information).

Design-builders rated the skill in question number eight (effectiveness in marketing and customer relations) higher (M = 5.63) than that expressed by constructors (M = 4.95) and architects (M= 4.52) as recorded in Table 16. Harrigan and Neel (1996) presents Luckman's opinion that the "human element is at the root of business success" (p. 19). Press (1998) argues that design students should "become adept at participating in a design process that is implicitly fluid and explicitly social;" that they should " build communities and develop tools for engaging in collaborative design" (p. 239). Bordogna (1998) wrote teams "...must be flexible, adaptable, and resilient...they must be able to view their work from a systems approach - across disciplines - and within the context of ethical, political, international, environmental, and economic considerations." (p. 48).

Design-builders rated the skill in question number seventeen, ability to generate business computer presentations using Powerpoint, higher (M = 4.30) than that expressed by constructors (M = 3.59) and architects (M = 3.48). Of the six question depicted in Figure 5, question 17 had the lowest mean score of all the professions (M = 3.76) as reported in Table 16. This may stem from the low likelihood that a newly hired graduate would be making presentations to clients right out of college. They are usually hired to perform services that generate positive and visible cash flow to the company. Again, quoting Luckman:

> The art of marketing a product, a service, a person, or a company lies in determining and then advertising those things that are unique and distinctive. Whether you're selling toothpaste, soap, or an architectural firm, your special, individual experience is as important as any other single ingredient. You have to demonstrate to the public just what makes you different from, and better than, your competitors. (p. 20)

Among the three professions, question 25, effectiveness in verbal communication (M = 6.29, SD = 0.80) received the second highest score. The literature contains numerous examples regarding this skill. Boyer and Mitgang (1996) quote an architect: "You see students who are well organized and good designers, but can't put two sentences together" (p. 80). Mead and Gehrig's (1995) survey placed communications skills at the top of constructors' skills. Quoting one of their panel of experts: "I don't sell construction, I sell people and communication." (p. 27).

Design-builders rated the skill in question number twenty-six (ability to use the Internet and e-mail routinely) higher (M = 5.07) than that expressed by constructors (M = 4.44). Design-builders were shown to rate that skill higher than architects (M = 4.61), but it was not determined to be statistically significant. This may be due to a design-builder client base of high-tech companies seeking compressed delivery times for the plants. Each day ahead of schedule that a plant is brought on line may yield millions of dollars in revenues for the client. The explosion of high-tech, dot-com, and virtual companies has created a dual economy. Last year, four companies of the thirty companies that make up the Dow Jones Industrial Average were been replaced by four companies that better reflected the present economy of the United States; one new company was Microsoft. Increasingly there is talk of the "new economy" versus the "old economy." A decade ago, a price earnings (P/E) ratio of 18 for a stock was deemed appropriate. Today, some high-tech/Internet companies have P/E ratios at an unheard of level of 100; and they haven't made a profit yet.

Greist (1996) argues that it is the "fast-paced world of business and communication" that is causing a "paradigm shift in how real estate developers, public and private sectors and business owners view the entire construction process" (p. 4B). Gregerson (1998) cites a 1995 CII study suggesting that design-build had less schedule growth compared to design-bid-build. Microelectronic, pharmaceuticals, and other high-tech firm have a need to bring their product to market quickly (Gregerson, 1998). The use of the Internet by constructors to communicate with clients is still small compared to its use as part of the firm's marketing mix, however, they see its importance as another tool to manage business (Schexnayder, Wiezel, & Seneviratne, 1999). This recent study contrasts a slightly older study by Chini, et. al., (1997), that recorded a mean score of only 2.0 out of 5 when measuring the importance of Internet competency and 2.1 out of 5 when measuring the importance of E-mail competency.

Constructors and design-builders rated the skill in question number twenty-eight (knowledge of accounting and finance) higher (M = 4.41 and M = 4.33, respectively) than the rating expressed by architects (M = 3.20). Constructors performing in the traditional design-bid-build project delivery system may be more conditioned by the hard-bid mentality where the lowest bid earns an awarded contract compared to the negotiated fee and fast-track nature found in design-build. Of the three types of people out there; those who get the work, those who do the work, and those who keep score, constructors spend more time than architects keeping score, monitoring project costs and schedules.

Recommendations for Further Research

Of the twenty-two questions that indicated valid significant differences among the three populations sampled, design-builders and architects, together, did not agree on the importance of any of the skills when compared to constructors. However, design-builders and constructors, together, did agree on fifteen of the twenty-two (sixty-eight percent) questions that indicated a significant difference among the three disciplines. Architects and constructors maintained similar views on only two questions (Questions 8 and 17), those regarding marketing and presentation skills, which were deemed less important compared to design-builders. The construct may be appropriate, but the test may fall short of measuring the element within the construct.

There may be a problem with criterion validity in the form of contamination. Do many design-builders view the process as merely a contractual commodity or as an integrated discipline? How many of the design-build firms in the study were originally founded as construction firms? The researcher would suggest a qualitative study, but, selection of appropriate design-builders would be an arduous task.

There may be intervening variables, such as the respondent's position in the company, years of experience, and the size and complexity of the firm's projects.

Respondents involved in residential construction, heavy engineering, and industrial segments of the market may be more heavily engaged in the design-build delivery system. Each market segment has differing issues with capitalization, market fragmentation, competition, customers, among others, and, therefore, pursue different strategies. Future studies may opt to select one of the four primary market segments.

The selection of the panel of experts utilized in the preliminary survey instrument (Appendix C) could have included design-builders. The existing panel was defined by registration or license; an appropriate panel of design-builders may prove thorny. The researcher is uncertain the design-build respondents were thinking of the strategic implications of requisite skills rather than responding as an architect or constructor would regarding the competencies and skills they seek in a graduate. Are the respondents pondering the graduate's productivity in an entry level position? Thinking in terms of a position instead of a set of skills may skew the results.

Recommendations for Changes in the Questionnaire

Demographic question number one, pertaining to the discipline that best represents the firm's business, should list "architect/engineer" instead of just "architect" and should list "contractor/specialty-contractor" instead of just "contractor" so the category "other" would not become a convenient place for some responses. Demographic question number two should specify "professional license" as opposed to just "license", as a few participants listed a "business license" in the "other" category.

Questions number three and sixteen should be reworded or eliminated due to low reliability. Question number three (Ability to do building layout on the site) was probably not understood by architects. The question had a reliability coefficient of 0.15 when compared to the nine questions relating to construction skills. Question number sixteen (Ability to write/interpret contracts) was probably rated high by architects due to the word "write" and high by constructors due to the word "interpret" and may need to be restated or separated. The question had a reliability coefficient of 0.09 when compared to the fourteen questions relating to architectural skills.

The design-builders responding to the open-ended question at the end of the survey instrument spoke less of technical skills and more of soft skills (people skills, communication skills, and character) and "big picture" perspectives, including conceptual estimating and constructability. Additional and more pertinent questions relating to soft skills could be developed through interviews with design-builders, owners, and facilities managers, to name a few, who utilize design-build.

While this study supports previous studies and opinions of experts in the fields of architecture and construction, the study suggests there are some skills that design-builders value more than architects and constructors. Primarily observed in questions number four, eight, and seventeen, design-builders appear to be sensitive to skills related to marketing. This is congruent with the tendency for design-builders to "negotiate work" compared with tendering a "hard bid."

Addition or Removal of Constraints

In order to delimit or narrow the study, selection of professionals according to the primary segment of the market for which they deliver services could be made. For example, one could survey only those firms whose primary work is in building construction rather than residential, heavy engineering, and industrial construction.

Variables or Conditions Difficult to Control

What is the true nature of the design-builders surveyed? Were many of the design-builders surveyed recently constructors that evolved to their present state or were they transformed by market changes leading to a strategic restructuring? Is their delivery system a convenient contractual relationship between two disciplines or a strategic transformation in thinking and operations? This quantitative survey was severely limited in selecting the breed of design-build firm. A future, more selective, qualitative study may prove more effective in understanding meaningful differences between design-builders and constructors.

Conclusions

There are differences among architects, constructors, and design-builders in the skills and competencies they seek in graduates. Although constructors and design-builders seem to share many of the same views, design-builders appear to favor skills that deal with marketing, communication, and interfaces between their firm and their clients'. This may be explained by their tendency to employ negotiated work as opposed to obtaining work through hard bidding. That tendency may be a result, as expressed by Sullivan (1997), of "two coincidental trends": owners' need for fast tracked building projects and the lack of the "professional" capital within the owner's team.

The key to winning design-build proposals goes beyond programming and aesthetic requirements that architects may stress, and cost and schedule considerations constructors may value. The owner's objectives may require the addition of financial and political objectives encompassing all levels of the design and building industry (Wundram, 2000). Combining the knowledge that the designer and builder possesses with the development of management systems ranging from teaming agreements to contracts in an effort to enhance communications and relations, requires a shift from the old paradigm (Warkol, 1997).

The shared views of design-builders and constructors may be explained if most of the design-build firms polled were originally contractors and are transitioning to offering design-build services. If those design-builders surveyed are constructors who understand design-build's strategic position to "get the work," then emphasis on marketing construction services may be all that is required of construction students pursuing a career with a design-build firm.

Is there a specialized knowledge base that would differentiate design-builders, architects, and constructors? They may possess technical skills on the occupational hierarchy from both fields, but require more interpersonal abilities on a technical and social continuum. Beder (1999) even suggests teaching beyond technicalities to include social and environmental impacts. It is easier to teach scientific courses where there is one right answer than courses that have ambiguous or real life problems which have many solutions. This has implications in higher education where subjective personal traits are difficult to evaluate and can become politically charged.

Requisite skills researched in this study and discussed by Chini, et. al. (1997), Mead and Gehrig (1995), Press (1998), Rounds (1992), and Young (1989) strengthens The Boyer Commission's Report (1998) recommending interdisciplinary undergraduate education. To a large degree, current construction education may be best suited to respond to the particular needs of design-builders. The addition of design courses may not be important for construction students. The data suggests that construction management majors, in order to enhance their prospects for placement in a design-build firm, should augment their education in the following general business areas: (a) marketing, (b) entrepreneuring and (c) presentations skills. A weaker argument would also suggest improving graphic communication skills and enhancing creative abilities.

Why do design-builders value "general business skills" such as adeptness as an entrepreneur (question 4), effectiveness in marketing and customer relations (question 8), and business presentations (question 17)? Do design-builders place a higher emphasis on "getting the work?" Philip Kotler's marketing text opens with a quote from Peter Drucker; "Marketing is so basic that it cannot be considered a separate function... It is the whole business seen from the point of view of its final result, that is, from the customer's view" (Kotler, 1988, p. 1). Young (1989) notes the construction industry's shift from "construction production" to "construction services" which will require a change in construction management education. Presentations, written and oral and on an interactive basis, are required. The ability to "think on your feet" to work in "real time" is important.

The master builders of the Renaissance had noblemen as clients, such as the Medici's. These owners placed more value with aesthetics over function. The church's power was replaced by the state, the free market society hasn't replaced the states power, but has overshadowed it by its influence. As the industrial revolution saw changes in production from home-based hand manufacturing to large-scale factory production, the information revolution has produced a new breed of client that requires an agile process, one void of a bureaucratic process, relying more on openness, trust, and communication. New owners are less interested in the historic roles of the building professions than what the professions can provide them. The process may be more important than the end product. Cumbersome and multiple contracts are at odds to the streamlined process owners seek. Understanding and satisfying the owners' needs and offering services to suit those needs requires a new view detached from the historic perspectives of the design and construction professions. This realization should trouble architectural education, and the architectural profession, as construction education is best suited to provide the skills design-builders seek in a graduate.

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APPENDICES

APPENDIX A

Panel of Experts

Panel of Experts

These experts answered either the initial two part open ended questions or the preliminary three page instrument.

Architect/ Designer

Bruce Douglas Fraser, AIA
Andrew J. Kavelaars, Designer
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971 Osos Street
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Thom Torvend & Associates
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Modesto, CA 95354

OWP&P
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Chicago, IL 60602

Constructor

Acme Construction
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Kevin Gilligan
Gilligan Homes
11941 W. 48th Avenue
Wheat Ridge, CO 80033

Joseph P. Baccarella
Projects Control Manager
Raytheon Engineers & Constructors
5555 Greenwood Plaza Blvd., Suite 100
Englewood, CO 80111

Darrell Eastwood
Project Executive
Saunders Construction Inc.
6950 S. Jordan Road
Englewood, CO 80155

Bob Shearer
Ryland Homes
8000 E. Maplewood Ave. Ste. 120
Englewood, CO 80111

Appendix B

Cover Letter Accompanying the Preliminary Survey Instrument

November 23, 1998

To selected
Architectural & Construction Office

As part of the final phase of my doctoral program in education at Colorado State University. I am asking for your assistance in validating my dissertation survey instrument.

The survey population of my research will be architects. constructors and those who identify themselves as design-builders. The first part of the questionnaire consists of 32 short questions relating to skills and competencies required in the field of architecture and construction. It is not meant to be an exhaustive list. but should represent major areas of knowledge and skills in the building industry.

The final part of the questionnaire begins with an open ended question allowing you to add your input. It is followed by demographic questions relating to your firm.

I trust you will find the questions are innocuous. On the right side of the questions is a box you may check if you feel you do not understand the question.

Please feel free to make comments anywhere on the survey instrument as your input is needed for validation of this study

Sincerely.

Paul A. Weber
PhD Candidate. Co-investigator

(970) 495-1894
paweber@lamar.colostate.edu

Appendix C

Preliminary Survey Instrument

Please note the time as the last question asks you how long it took you to answer this questionnaire.

Check box if question is not clear

The purpose of this questionnaire is to gather information from Architectural, Construction and Design-build firms in order to evaluate the similarities and differences in requisite skills valued in their respective professions. The person answering this survey should be in a position that would evaluate, for the firm, potential graduates applying for a position in the firm. The applicants would be those that are expected to rise to upper level positions in the firm.

Please indicate how important you would find the following skills and competencies in a graduate of a design or construction program your firm would consider hiring.

The scale is arranged from 1 to 7, ranging from
1 being <u>not important</u> to
7 being <u>extremely important</u>.

Check box if question is not clear

		not important						extremely important	
1.	Ability to create, maintain and enhance effective working relationships:	1	2	3	4	5	6	7	☐
2.	Ability to write/interpret specifications:	1	2	3	4	5	6	7	☐
3.	Ability to do building layout:	1	2	3	4	5	6	7	☐
4.	Adeptness as an entrepreneur:	1	2	3	4	5	6	7	☐
5.	Ability to use word-processors and spreadsheets routinely:	1	2	3	4	5	6	7	☐
6.	Ability to problem solve:	1	2	3	4	5	6	7	☐
7.	Ability in graphic/hand communication:	1	2	3	4	5	6	7	☐
8.	Effectiveness in marketing and customer relations:	1	2	3	4	5	6	7	☐
9.	Effectiveness in written communication:	1	2	3	4	5	6	7	☐
10.	Creativity ability:	1	2	3	4	5	6	7	☐
11.	Knowledge of use of materials and methods of construction:	1	2	3	4	5	6	7	☐
12.	Knowledge of local codes (building, planning):	1	2	3	4	5	6	7	☐
13.	Ability to understand integration of systems:	1	2	3	4	5	6	7	☐

	not important						extremely important	Check box if question is not clear
14. Ability to perform value engineering or life cycle costs of a project:	1	2	3	4	5	6	7	☐
15. Knowledge of Model Codes (BOCA, SBC, UBC):	1	2	3	4	5	6	7	☐
16. Ability to write/interpret contracts:	1	2	3	4	5	6	7	☐
17. Ability to generate business computer presentation using Powerpoint:	1	2	3	4	5	6	7	☐
18. Knowledge of safety laws (such as OSHA):	1	2	3	4	5	6	7	☐
19. Knowledge of theory of architectural design and architectural history:	1	2	3	4	5	6	7	☐
20. Ability to graphically solve problems:	1	2	3	4	5	6	7	☐
21. Ability to develop a simple schedule (such as a bar chart) for a project:	1	2	3	4	5	6	7	☐
22. Ability to use computer software to generate sophisticated schedules (such as Primavera):	1	2	3	4	5	6	7	☐
23. Ability to estimate cost of structures:	1	2	3	4	5	6	7	☐
24. Ability to think spatially, in three dimensions:	1	2	3	4	5	6	7	☐
25. Effectiveness in verbal communication:	1	2	3	4	5	6	7	☐
26. Ability to use the Internet and e-mail routinely:	1	2	3	4	5	6	7	☐
27. Ability to use estimating software programs (such as Timberline):	1	2	3	4	5	6	7	☐
28. Knowledge of accounting and finance:	1	2	3	4	5	6	7	☐
29. Knowledge of structural theory:	1	2	3	4	5	6	7	☐
30. Ability to use CAD programs routinely (such as AutoCAD):	1	2	3	4	5	6	7	☐
31. Ability to plan construction project execution:	1	2	3	4	5	6	7	☐
32. Ability to monitor project costs:	1	2	3	4	5	6	7	☐

Are there other skills and competencies your believe should be included in this questionnaire (use the back if you require more space)?

Check box if question is not clear

1. Please check one of the following that best represents your firm's business. ☐
❑ Architecture ❑ Construction ❑ Design-Builder
❑ Other ________________ (specify)

2a. Licenses held by the firm: (Check all that apply)
❑ Architect ❑ Contractor ❑ Engineer ❑ Other ________________ ☐

2b. If you checked Contractor, what type of Contractor
❑ General Contractor ❑ Specialty Contractor ❑ Construction Manager ☐

3a. Is your firm involved in design-build?
❑ Yes ❑ No ☐

3b. If your firm is involved in design-build, are you involved as an integrated firm or through joint ventures?
❑ Integrated design-build firm ❑ Joint ventures ❑ Both ☐

3c. Percent of firm's work in design-build? _______% ☐

4. What percentage of work is performed in the following industry segments: ☐

Residential ____%
Single-family, Multi-unit town houses, High-rise apartments, Condominiums

Building Construction ____%
Schools, Universities, Hospitals, Commercial Office Towers, Warehouses, Light Manufacturing Plants, Theaters, Government Buildings, Commercial Malls, Recreation Centers

Heavy Engineering ____%
Dams, Tunnels, Bridges, Highways, Airports, Urban Transit Systems, Ports, Pipelines, Water Treatment Plants, Communication Networks

Industrial ____%
Petroleum Refineries, Petrochemical Plants, Synthetic Fuel Plants, Nuclear Power Plants, Steel Mills, Heavy Manufacturing Plants

Total 100%

5. Company Size: Number of Personnel
❑ 1-5 ❑ 6-10 ❑ 11-20 ❑ 21-50 ❑ 51-100 ❑ over 100

6. Your firm's construction work annual volume:
❑ $0-$5 Million ❑ $5-$10 Million ❑ $10-$50 Million ❑ $50-$100 Million
❑ $100-$200 Million ❑ $200-$500 Million ❑ over $500 Million

How long did it take you to answer this questionnaire? _________ minutes.

Appendix D

Skills and Competencies List

Skills and Competencies List

Architecture

Personal Traits/Abilities

1	Creativity ability:	Q 10
2	Ability to think spatially, in three dimensions:	Q 24
3	Ability to problem solve:	Q 6
Architecture/Engineering Theory		
4	Knowledge of theory of architectural design and architectural history:	Q 19
5	Knowledge of structural theory:	Q 29
6	Knowledge of use of materials and methods of construction:	Q 11
7	Ability to understand integration of systems:	Q 13
Institutional/Societal		
8	Knowledge of Model Codes (BOCA, SBC, UBC):	Q 15
9	Knowledge of local codes (building, planning):	Q 12
10	Ability to write/interpret specifications:	Q 2
11	Ability to write/interpret contracts:	Q 16
Technical		
12	Ability to graphically solve problems:	Q 20
13	Ability in graphic/hand communication:	Q 7
14	Ability to use CAD programs routinely (such as AutoCAD):	Q 30

Construction

15	Ability to plan construction project execution (scheduling, site utilization):	Q 31
16	Ability to estimate cost of structures:	Q 23
17	Ability to use estimating software programs (such as Timberline):	Q 27
18	Ability to develop a simple schedule (such as a bar chart) for a project:	Q 21
19	Ability to use computer software to generate sophisticated schedules (such as Primavera)	Q 22
20	Ability to monitor project costs:	Q 32
21	Ability to perform value engineering or life cycle costs of a project:	Q 14
22	Ability to do building layout:	Q 3
23	Knowledge of safety laws (such as OSHA):	Q 18

General Business

Self-

24	Effectiveness in verbal communication:	Q 25
25	Effectiveness in written communication:	Q 9
26	Ability to create, maintain and enhance effective working relationships:	Q 1
27	Effectiveness in marketing and customer relations:	Q 8
28	Adeptness as an entrepreneur:	Q 4
Computer-		
29	Ability to use word-processors and spreadsheets routinely:	Q 5
30	Ability to generate business computer presentation using Powerpoint:	Q 17
31	Ability to use the Internet and e-mail routinely:	Q 26
Business-		
32	Knowledge of accounting and finance:	Q 28

Appendix E

Human Research Committee Form

Human Research Committee Form

Part C. Protocol Information

Objectives

1. Objectives of proposed research and background. (Will be used in assessing the risk/benefit ratio for participants. The hypotheses to be tested may be listed.)

   The purpose of this study is to measure differences among three building professionals: architects, constructors (contractors) and design-builders regarding competencies and skills they desire in graduates of design and/or construction programs. See the attached research questions.

Human Participants description

2. Source of participant population

   The sample of 108 architects will be drawn from an Internet directory (http://www.cmdg.com/profile/search.html). The sample of 108 constructors will be drawn from the 1998 directory of the American Institute of Constructors (AIC). The sample of 108 design-builders will be drawn from the 1998 directory of the Design-Build Institute of America (DBIA).

3. Number of participants

   The total number of participants invited to participate will be approximately 324.

4. Characteristics of participants (such as age, gender, student, disease conditions, behavioral abnormalities; affiliations or memberships)

   All participants are practitioners of architecture and/or construction. They are typically male, graduates of college or are seasoned office personnel and associated with professional organizations such as the AIC and the DBIA. Some of the architects may be members of the American Institute of Architects (AIA).

5. Recruitment procedures

   As outlined in the methodology chapter, national directories/rosters will be used to systematically select 108 architects, 108 constructors and all 108 members of the DBIA that identify themselves as design-builders. A cover letter (see attached) with a three page questionnaire (see attached) and a self addressed stamped envelope will be sent to the selected sample. Each instrument will have a number placed on the upper right-hand corner so the researcher can identify which responses have not been returned. Their actions, after receiving the questionnaire, are voluntary. Two weeks after the initial mailing, a thank you/reminder post card (see attached) will be mailed to those who have not responded. One week later a phone call will be made to non-respondents to inquire if they have, in fact, received the questionnaire.

6. Recruiting materials (attach advertisements, posters, letters, telephone scripts)
   Cover Letters

7. Criteria for including or excluding participants
   The primary criteria for including or excluding a participant shall be professional experience.

8. Rationale for using "at-risk" populations (e.g., minors, pregnant women, prisoners)
   NA

9. Original letters of HRC agreement/approval from organization where participants sought
   NA

10. Other matters pertinent to the human participants
    NA

Procedures to be followed with participants (Methodology)

11. Specify location of study
    The United States

12. List variables to be studied
    Independent Variables: The type of business the firm is engaged in, the professional licenses held by the firm, the firm's participation in the design-build project delivery method, the company size by the number of personnel and the annual dollar volume of construction work.

13. Describe method of data collection (attach copies of surveys, instruments, etc. If using a copyrighted instrument, document authorization of use.)
    Questionnaire. See attached 3 page questionnaire

14. Describe activities involving participants, including frequency and duration of each activity (this could be an experimental stimulus, a survey, what questions would be asked in an interview, for example)
    Completion of a questionnaire. It should take approximately 10-15 minutes.

15. Describe equipment used with subjects, if any
    NA

16. Specify what factors will lead to stopping procedures causing physical or emotional stress
    NA

17. Describe biological samples to be taken, method, and qualifications of individuals taking samples
    NA

18. Provide de-briefing method and materials for participants
    NA

19. Other aspects of the procedures
    See methodology.

Risks to participants

20. Describe potential risks and assess the likelihood, severity, duration, and effects of each. (Use "no known risks" if none are anticipated.)
    a. physical injury -no known risks
    b. psychological trauma or stress -no known risks
    c. social/economic harm -no known risks
    d. legal risk -no known risks
    e. loss of confidentiality -no known risks

21. Describe methods for minimizing risks. For example, document how potential psychological distress will be addressed, by whom, and with what credentials (provide letter of agreement to serve as a counselor)

    NA

22. Describe other methods, if any, that were considered alternatively and why they will not be used

    NA

23 Other matters relative to risk to participants

    NA

Benefits to participants

24. Describe the direct benefits to these participants because of their participation

    There are no direct benefits to the participants and no known risk.

25. Describe the benefits accruing to the class of participants these individuals represent

    Centuries ago the "master builder" was charged with the design and construction of structures. In this age, Architects an Constructors, by division of labor, play separate and distinct roles. The current trend is to join the design and construction disciplines in a project delivery system called "design-build." Information from this study may inform design and construction students pertaining to cross-over skills needed in the design-build field. This will serve the building industry by affecting the training of graduates they hire.

26. Describe the benefits accruing to society-at-large or other

    Graduates of building programs may receive more relevant training.

27. Other aspects of benefits to participants

    They can voice their position regarding the importance of various skills/competencies they desire in graduates of design and construction programs.

Consent procedures

28. Describe how potential participants will be informed about the project activities

    NA

29. Attach the consent form (*use reading level and terminology understandable to participants*) or cover letter

    NA

30. Other aspects of the consent process

"Implied consent" is assumed when participants voluntarily complete questionnaires and return them.

Confidentiality

31. Describe the method(s) used to protect the identity of individual participants

Participants will not be asked to reveal their names or their company names on the survey. A number placed on the upper right-hand corner of the questionnaire will only be used to track non-respondents for porposes of a follow-up post card and phone call. Once the data is entered into the database the number on the top corner will be cut off and discarded. All participants and their responses will remain completely anonymous.

32. Describe plans for maintaining data after study is complete

The original survey data (the returned questionnaires) will be filed and maintained solely by the co-researcher and not distributed to any other parties for any reason. The data shall be maintained on disks and in hard copy.

33. Describe how federal requirement will be met for consent forms to be retained for 3 years following the conclusion of the project. Typically this entails the faculty member storing the documents in locked storage.

NA

34. If audio- or video-taping, specify tape storage, use, and when and how disposition of the tapes will take place

NA

35. Other aspects of confidentiality

Participants are asked descriptive questions pertaining to their firm and the questions are innocuous. Questions measuring the dependent variables are not personal.

Appendix F

Approval by Human Research Committee

Approval by Human Research Committee

Colorado State University Human Research Committee
Application to Use Human Subjects (H-100, Rev 4/98)

[illegible]

Action of the CSU Human Research Committee

- ☒ Approved as exempt research — Approval number: [illegible] — Period: [illegible]
- ☐ Approved as non-exempt research — Approval number: ______ — Period: ______
  - ☐ Conditions: use of approved consent form
  - ☐ Other (see attachment for details)
- ☐ Cannot be approved as currently submitted (see attached memo for details)
- ☐ Tabled (see attached memo for details)

HRC Authorization: [signature] — Date: [illegible]

Part A Cover Sheet ☒ New Protocol ☐ Resubmission

1. Project Title: **Requisite skill differences of baccalaureate graduates among the buildings disciplines**
2. Principal Investigator (PI): **Allan Hauck** 3. Telephone: **491-5215**
4. Department: **Manufacturing Tech. & Constr. Mgt.** Email: **hauck@cahs.colostate.edu**
5. Co-Principal Investigator: **Paul Weber** Telephone: **495-1894**
6. Department: **School of Education/ MTCM** Email: **paweber@lamar.colostate.edu**

If Co-PI is a student, is this project for a ☐ Thesis ☒ Dissertation ☐ Seminar

[illegible]

Date project activity to begin: **December 16, 1998 or upon approval of application**

Will this project be supported by external funds? ☐ Yes ☒ No

13. Funding Agency [illegible]

14. Grant/contract number 15. Proposal deadline

[illegible]

PI Signature: [signature] Date: [illegible]

Department Chair/Head or Acting (circle which) Signature

[illegible]

Signature: [signature] Date: [illegible]

Appendix G

U.S. Census Bureau Population by State

U.S. Census Bureau Population by State (1997)

State	Population	ASC Region
Alabama	4,319,154	2
Alaska	609,311	6
Arizona	4,554,966	6
Arkansas	2,522,819	5
California	32,268,301	6
Colorado	3,892,644	4
Connecticut	3,269,858	1
Delaware	731,581	1
Dist. of Co.	528,964	1
Florida	14,653,945	2
Georgia	7,486,242	2
Hawaii	1,186,602	6
Idaho	1,210,232	6
Illinois	11,895,849	3
Indiana	5,864,108	3
Iowa	2,852,423	4
Kansas	2,594,840	4
Kentucky	3,908,124	3
Louisiana	4,351,769	5
Maine	1,242,051	1
Maryland	5,094,289	1
Massachusetts	6,117,520	1
Michigan	9,773,892	3
Minnesota	4,685,549	4
Mississippi	2,730,501	2
Missouri	5,402,058	4
Montana	878,810	6
Nebraska	1,656,870	4
Nevada	1,676,809	6
New Hampshire	1,172,709	1
New Jersey	8,052,849	1
New Mexico	1,729,751	6
New York	18,137,226	1
North Carolina	7,425,183	2
North Dakota	640,883	4
Ohio	11,186,331	3
Oklahoma	3,317,091	5
Oregon	3,243,487	6
Pennsylvania	12,019,661	1
Rhode Island	987,429	1
South Carolina	3,760,181	2
South Dakota	737,973	4
Tennessee	5,368,198	2
Texas	19,439,337	5
Utah	2,059,148	6
Vermont	588,978	1
Virginia	6,733,996	1
Washington	5,610,362	6
West Virginia	1,815,787	1
Wisconsin	5,169,677	3
Wyoming	479,743	4
TOTAL	267,636,061	

Percentage of the general population in the ASC Regions

Region 1 24.8%
Region 2 17.1%
Region 3 17.9%
Region 4 8.6%
Region 5 11.1%
Region 6 20.6%
100%

Source: http://www.census.gov/population/estimates/state/ST9097T1.txt

Appendix H

Selection Process for the Architect Database

Selection Process for the Architect Database

Constructors and design-builders were selected from national directories of the American Institute of Constructors (AIC) and the Design Build Institute of America (DBIA) respectively. To maintain a parallel track in the selection of architects, an obvious choice is to select members of the AIA. The population of members of the AIA is between approximately 60,000 to 70,000 members depending on the source queried. A representative from the national headquarters of the AIA in Washington, D.C. directed the researcher to the American List Counsel (ALC). Their response to the question regarding AIA membership differed by a few thousand from the AIA. Due to costs, a complete list of AIA members from the ALC, which is in the business of selling lists, cannot reasonably be obtained. State AIA directories apparently exist although access is troublesome.

Since access to state AIA directories is difficult, other methods were sought. The next tactic was to obtain a list using national phone directories. One on-line source, Big Yellow (http://bigyellow.com) generates yellow page listings by business, by state, and by city. By querying the directory about architects, state-by-state, with the "city" dialog box left blank, a list of architects for any particular state could be generated. The following states, for example, generated numerous business listings for architects: Alabama, 470; California, 8,219; Colorado, 1,245.

A list of architects in Boulder, Colorado was generated from the Internet directory to facilitate the distribution of a preliminary survey instrument to the panel of experts in architecture. Selection of those architects was based on convenience to distribute the preliminary survey instrument, so the downtown business district was chosen. As the preliminary survey instruments were dropped off at offices in Boulder, the first architect office selected from the Internet directory did not exist at the address listed. The second office selected also did not exist. However, the phone number listed was a toll-free number and so a phone call was placed. The architect answering the phone stated that their downtown Boulder office was closed down about 6 years ago. The office has been in Telluride, Colorado since then.

Another on-line directory, the "GTE Superpages" (http://yp2.superpages.com) listed 5,912 architects in California compared to BigYellow's 8,219. However, inadvertently, the researcher recognized one of the listings of architects in San Luis Obispo, California as the name of an architectural designer who is not a registered architect. How these lists were generated is dubious. This suggests that on-line telephone directories are not currently reliable.

State government home-pages were accessed via the Internet in the hopes to link to their Architectural Registration Boards. The state home page addresses are similar in form. For example Texas' is http://www.state.tx.us/ and Florida's is http://www.state.fl.us/. Of the six states chosen in this study (New York, Florida, Illinois, Missouri, Texas and California), only the California Board of Architectural Examiners (http://www.cbae.cahwnet.gov/) had an accessible list of architects licensed in the state, all 22,000, available under a searchable licensee query in an Adobe Acrobat Reader PDF (portable document format) format (http://www.cbae.cahwnet.gov/pdf/98roster1.pdf). Since the researcher needed to select 22 architects from California, that would require selecting every 1,000th architect on the list; a laborious task.

A recent list of AIA member firms with web sites, available on-line through the AIA web site (http://wwwaia.org) found at http://www.e-architect.com/reference, appeared more relevant than the on-line yellow page directories. The sites sampled appear to be progressive firms reflecting large and small practices, and at least exhibit contemporary information. This list may have a built-in bias due to the firm's accent in advanced technology. Of six states chosen to represent various regions, the total number of websites per state, as of December 1, 1998, were as follows: New York, 93; Florida, 79; Illinois, 55; Missouri, 28; Texas 95 and California, 200. Since some firms have licenses in numerous states, not all sites are of firms operating solely in that state. If 27 architects needed to be selected in the state of New York, which contained 93 sites, almost three of every five architectural firms would have been needed to be selected which lessened the characteristic of randomization.

The web site for the American Institute of Architects, California Council (AIACC) (http://www.sfo.com/~coredata/aiacc/aiacc.htm) revealed approximately 8,500 members: a more beneficial number than the 200 architects listed on "e-architect" and more manageable than the 22,000 listed by the California Board of Architectural Examiners. Each state chapter of the AIA has their own roster of members. Six state chapters would have had to be contacted to purchase a roster of state AIA members. A more convenient method was discovered as recorded in Chapter 3.

Appendix I

Cover Letter for Final Survey Instrument

January 6, 1999

A/E/C Professional
Address
City, Town, Zip

Dear *Profesional*:

As part of the process of completing work on my Ph.D. at Colorado State University, I am conducting research on the differences among architects, constructors and design-builders regarding competencies and skills they perceive as being important in newly hired graduates.

You have been selected randomly from a national list of design and construction professionals. Although the questions are innocuous and not personal, each questionnaire is numbered to allow confirmation of return. This tracking number will be removed upon return so your answers will remain anonymous. It will also facilitate in providing you a brief summary of this study if you check the last box in the questionnaire.

The response to the questionnaire should reflect the criteria for selecting and hiring design or construction graduates for your firm. The questionnaire should take approximately 10 minutes to complete.

Your input and participation in this study is vital and greatly appreciated. Dissemination of the results of this study may influence design and construction education.

Please mail the completed questionnaire utilizing the enclosed pre-addressed envelope. If you have questions you may contact me by phone (970) 495-1894 or by e-mail: paweber@lamar.colostate.edu

Thank you for your input and assistance with this research.

Sincerely,

Paul Weber
Ph.D. Candidate

Appendix J

Final Survey Instrument

The purpose of this questionnaire is to gather information from Architectural, Construction and Design-build firms in order to evaluate the similarities and differences in requisite skills valued in their respective professions. The person answering this survey should be in a position that would evaluate, for the firm, potential graduates applying for a position in the firm who are expected to eventually manage projects.

Please indicate how important you would find the following skills and competencies in a graduate of a design or construction program your firm would consider hiring. Circle the appropriate number.

The scale is arranged from 1 to 7, ranging from
1 being not important to
7 being extremely important.

		not important						extremely important
1.	Ability to create, maintain and enhance effective working relationships	1	2	3	4	5	6	7
2.	Ability to write/interpret specifications	1	2	3	4	5	6	7
3.	Ability to do building layout on the site	1	2	3	4	5	6	7
4.	Adeptness as an entrepreneur	1	2	3	4	5	6	7
5.	Ability to use word-processors and spreadsheets routinely	1	2	3	4	5	6	7
6.	Ability to problem solve	1	2	3	4	5	6	7
7.	Ability in graphic/hand communication	1	2	3	4	5	6	7
8.	Effectiveness in marketing and customer relations	1	2	3	4	5	6	7
9.	Effectiveness in written communication	1	2	3	4	5	6	7
10.	Creative ability	1	2	3	4	5	6	7
11.	Knowledge of use of materials and methods of construction	1	2	3	4	5	6	7
12.	Knowledge of local codes (building, planning)	1	2	3	4	5	6	7
13.	Ability to understand integration of systems	1	2	3	4	5	6	7
14.	Ability to perform value engineering or life cycle costs of a project	1	2	3	4	5	6	7
15.	Knowledge of Model Codes (BOCA, SBC, UBC)	1	2	3	4	5	6	7
16.	Ability to write/interpret contracts	1	2	3	4	5	6	7

		not important						extremely important
17.	Ability to generate business computer presentation using Powerpoint	1	2	3	4	5	6	7
18.	Knowledge of safety laws (such as OSHA)	1	2	3	4	5	6	7
19.	Knowledge of theory of architectural design and architectural history	1	2	3	4	5	6	7
20.	Ability to graphically solve problems	1	2	3	4	5	6	7
21.	Ability to develop a simple schedule (such as a bar chart) for a project	1	2	3	4	5	6	7
22.	Ability to use computer software to generate sophisticated schedules (such as Primavera)	1	2	3	4	5	6	7
23.	Ability to estimate cost of structures	1	2	3	4	5	6	7
24.	Ability to think spatially, in three dimensions	1	2	3	4	5	6	7
25.	Effectiveness in verbal communication	1	2	3	4	5	6	7
26.	Ability to use the Internet and e-mail routinely	1	2	3	4	5	6	7
27.	Ability to use estimating software programs (such as Timberline)	1	2	3	4	5	6	7
28.	Knowledge of accounting and finance	1	2	3	4	5	6	7
29.	Knowledge of structural theory	1	2	3	4	5	6	7
30.	Ability to use CAD programs routinely (such as AutoCAD)	1	2	3	4	5	6	7
31.	Ability to plan construction project execution (scheduling, resource leveling, site utilization)	1	2	3	4	5	6	7
32.	Ability to monitor project costs	1	2	3	4	5	6	7

Are there other skills and competencies you believe should be included in this questionnaire? (please use the back of this sheet if you require more space)

Information about your firm

1. Please check one of the following disciplines that best represents your firm's business.
❑ Architecture ❑ Construction ❑ Design-build
❑ Other ____________________ (please specify)

2a. What licenses are held by the firm: (Check all that apply)
❑ Architect ❑ Contractor ❑ Engineer
❑ Other ____________________ (please specify)

2b. If you checked Contractor, what type of Contractor
❑ General Contractor ❑ Construction Manager ❑ Specialty Contractor

3a. Is your firm involved in design-build?
❑ Yes ❑ No *(if no, go to question 4)*

3b. If your firm is involved in design-build, is it involved as an integrated firm or through joint ventures or both?
❑ Integrated design-build firm ❑ Joint ventures ❑ Both

3c. What percent of your firm's work is in design-build? __________%

What percentage of work is performed in the following industry segments:

4a. **Residential** ________%
Single-family, Multi-unit town houses, High-rise apartments, Condominiums

4b. **Building Construction** ________%
Schools, Universities, Hospitals, Commercial Office Towers, Warehouses, Light Manufacturing Plants, Theaters, Government Buildings, Commercial Malls, Recreation Centers

4c. **Heavy Engineering** ________%
Dams, Tunnels, Bridges, Highways, Airports, Urban Transit Systems, Ports, Pipelines, Water Treatment Plants, Communication Networks

4d. **Industrial** ________%
Petroleum Refineries, Petrochemical Plants, Synthetic Fuel Plants, Nuclear Power Plants, Steel Mills, Heavy Manufacturing Plants

Total 100%

What size is your company:

5. Number of Personnel
❑ 1-5 ❑ 6-10 ❑ 11-20 ❑ 21-50
❑ 51-100 ❑ over 100

6. Your firm's annual volume of work in terms of construction put in place:
❑ $0-$5 Million ❑ $5-$10 Million ❑ $10-$50 Million ❑ $50-$100 Million
❑ $100-$200 Million ❑ $200-$500 Million ❑ over $500 Million

Thank you for taking some of your valuable time in responding to this questionnaire!

If you would like to receive a summary of the results please check this box: ❑

Appendix K

Follow-up Post Card and Follow-up E-mail Note

Follow-up Post Card

January 22, 1999

Colorado State University
Department of Manufacturing Technology and Construction Management
Fort Collins, Colorado 80523-1584

Dear Colleague,

A few weeks ago you should have received a letter and a questionnaire from me inquiring about requisite skills desired by Architects, Constructors, and Design-Builders as part of my doctoral research in Education at Colorado State University.

Thank You for your response if you have already completed and returned the questionnaire. So far, the response has been excellent!

If you have not done so, I would appreciate your assistance. Your input is vital for the strength of the research. The data will remain confidential and will benefit architectural and construction education. If you did not receive the questionnaire and would like to obtain one, please write to me at the above address, or phone 970-495-1894 or e-mail: paweber@lamar.colostate.edu

Thank you,

Paul A. Weber
Ph.D. Candidate/ Co-investigator

Follow-up E-mail Note

February 21, 1999

Name: XXXXX
Address: XXXXX *[to ensure the correct address was used]*

Dear XXXXX,

Last month you should have received a questionnaire from me inquiring about requisite skills desired by Architects, Constructors, and Design-Builders as part of my doctoral research in Education at Colorado State University.

I am contacting you to determine if you have received this questionnaire. If you have not received the questionnaire and are willing to contribute to the study please respond to this message and I will mail the questionnaire along with a postage paid return envelope to you. Responding to the questions should take no more than 10 minutes.

The additional data I receive in the next few weeks can easily be added to my current data file; it's not too late! Your input will enhance the validity of the research. The data will remain confidential and will benefit architectural and construction education.

Thank you,

Paul A. Weber
Ph.D. Candidate/ Co-investigator

Appendix L

Data Entry Code Book

Code Book

Dependent Variables

Original assignment using tracking numebers

	Architects	1-108	=	1
	Constructors	200-308	=	2
	Design-Builders	400-508	=	3

Questions 1-32: Skill/Competency Likert Scale	not important	=	1
			2
			3
			4
			5
			6
	extremely important	=	7
	no answer:	=	*0*

Independent Variables

Q 1.	Firm type:	Architect	=	1
		Contractor	=	2
		Design-Builder	=	3
		Other	=	4
		no answer:	=	*0*

Rule: if more than one box was checked, original source directory was used

Q 2a.	Licenses held:	Architect	=	1
		Contractor	=	2
		Engineer	=	3
		Other	=	4
		More than one:	=	5
		no answer:	=	*0*
Q 2b.	Contractor type:	General (G.C.)	=	1
		Constr. Mgr. (CM)	=	2
		Specialty	=	3
		no answer:	=	*0*

Rule: if G.C. And C.M. Were both checked, G.C. Was used

Q 3a.	Involved in design-build:	Yes	=	1
		No	=	2
		no answer:	=	*0*

Q 3b. Type of design-build:	Integrated	=	1
	Joint venture	=	2
	Both	=	3
	no answer:	=	*0*

Q 3c. Percentage of design-build: = _____%

Industry segments performed in:

Q 4a.	Residential	=	_____%
Q 4b.	Building Construction	=	_____%
Q 4c.	Heavy Engineering	=	_____%
Q 4d.	Industrial	=	_____%

Company Size:

5. Number of personnel

1-5	=	1
6-10	=	2
11-20	=	3
21-50	=	4
51-100	=	5
Over 100	=	6
no answer:	=	*0*

6. Gross construction work annual volume:

$0-$5 Million	=	1
$5-$10 Million	=	2
$10-$50 Million	=	3
$50-$100 Million	=	4
over $100 Million	=	5
no answer:	=	*0*

Last question:

Would you like to receive a summary of the results?

No. no answer	=	1
Yes	=	2

Scores to be summed and averaged in SPSS:

SS1. Architecture/Engineering summated skills:

Add questions: 10, 24, 6, 19, 29, 11, 13, 15, 12, 2, 16, 20, 7, 30

divide by 14 for an average

SS2. Construction summated skills

Add questions: 31, 23, 27, 21, 22, 32, 14, 3, 18

divide by 9 for an average

SS3. General Business summated skills

Add questions: 25, 9, 1, 8, 4, 5, 17, 26, 28

divide by 9 for an average

Appendix M

Responses to Open-ended Question

Summary of Open-ended Question
Responses by discipline

Are there other skills and competencies you believe should be included in this questionnaire?

Architects

Architect #1

The more you manage the knowledge of law/finance/construction is required -for Architects- many are doing design/build to get more fees and more authority -also more liability-many Architects do construction management-with no liability-just a big piece of the pie $ from Architect's fee typically-

Architect #2

Your #1 almost says it: Personableness: easy to get along with.

Architect #3

I believe that much of these items (such as 15. or 18) can be learned. What cannot be learned it is common sense and good work ethic. An educated person without these is not worth much.

[15. Knowledge of Model Codes (BOCA, SBC, UBC):]

[18. Knowledge of safety laws (such as OSHA):]

Architect #4

Hand drafting?
Can they draw- both computer and hand?
Can they or are they able to prepare construction drawings/permits?

Architect #5

33. Ability to be a team player.
34. Strong work ethic.

Architect #6

Architecture schools today place too much emphasis on the use of computers-computers encourage compartmentalization thought processes- by their nature they limit the users ability to see the 'big picture." An architect must start with generalizations and progress to specifics through a logical series of steps. Design and design development must start with freely expressed concepts-the only way I know how to do this is with pencil and paper. The computer it is a drafting tool only! The architect should understand its use but must also understand its function. In the same way an architect should be able to "draft" (in the old sense) -he did not always functioned as his own "draftsman" -In my experience people who are good with computers, who like to use computers, who feel intrigued by the computer and its use are not often good designers-they are technicians-"draftsmen".

Architect #7

1-32 more than covers the desirable skills..

Architect #8

I guess "ability in graphic/hand communication"
Includes drafting? Skills important to me.
In an employee- CAD especially 3D.
Manual drafting, especially renderings.
Ability to follow instructions/standard office methods.
Previous work experience/resume'.

Architect #9

-Ability to work as a team, not just an individual.
-Recognition of lack of experience, but willingness to learn.
-Incentive to constantly learn.

Architect #10

33. Ability to work closely with others on construction team.
34. Personal interaction skills.
35. Ability to assess situations. Identify and respond appropriately to critical situations. Good under pressure.

Architect #11

The questionnaire is ambiguous. I would have different criteria for a designer or a construction program Graduate. I used designer criteria.

Architect #12

The most important skill is reliability. We can teach him the skills he really needs to help us. I want and employee who first shows up on time every day without a hangover.

Constructors

Constructor #1

Leadership skills.

Constructor #2

Sense of humor
Ethics
Tenacity
People management skills
Perspective/sense of proportion

Ability to learn

Constructor #3

The ability to think is important as well as a good work ethic.

Constructor #4

The ability to make information flow effectively up and down the chain of command-all parties receiving timely and accurate information to facilitate decisions-kind of a part on # 9.

[9. Effectiveness in written communication:]

Constructor #5

Labor law. FLSA [Fair Labor Standards Act], Davis-Bacon. tax sector. how to deal with confrontation.

Constructor #6

33. Knowledge of organizational management (leadership, motivation, etc.).

Constructor #7

Ability to research/analyze alternative materials and processes.
Business Machines-10 key calculator, typewriter, calculator, phones.
Meeting and documentation management.
Inquisitiveness- Spirit of continuous learning.

Constructor #8

-Plan reading
-Conceptual estimating
-Design/build process (knowledge of)

Constructor #9

-Knowledge of management concepts and philosophies.
-Ability to read an understand drawing[s] and specifications.

Constructor #10

Practical approach to solution of problems.

Constructor #11

Time management skills.

Constructor #12

Honesty
Integrity
Cooperative effort approach

Constructor #13

This is based on a new hire[d] graduate well [with] limited work experience. It's important that they have a broad knowledge but at this stage of the development I'm not sure they need to be strong and one particular skill. They do need to have a good communication skills (written and verbal). They need to have good at problem solving skills and the ability to get along with others. The process and good OJT [on-the-job-training] and continued education will develop the[ir] finer points in what they need to contribute and progress.

Design-builders

Design-builder #1

We have had great difficulty in finding young people with practical knowledge. Most are very good on a computer. They can prepare amazing presentations that are all glitz and glitter, but void of practicality. Two things that young engineers are missing are business knowledge and "Constructability" of designs.

Design-builder #2

Ability to work as part of a team.
Ability to work independently.

Design-builder #3

Field experience in terms of how a building is constructed.

Design-builder #4

Project management methodology or international standards (Project Management Institute's Project Management Body of Knowledge).

Design-builder #5

Ability to deal with people and communicate ideas effectively. Strong people skills.

Design-builder #6

I've checked <u>too</u> many 7's which makes one predisposed to discount [the] response. My belief- you either must be the best specialists or the best generalist- the latter requires a strong ability to [do] most everything well- foremost- relationships and all forms of communication. We look for people that are like Velcro- lots of things that will stick-

Best of luck

Design-builder #7

33. Ability to generate conceptual estimates.

Design-builder #8

Questionnaire should be organized between architectural/construction person being hired. As a design-build firm it's hard to answer for with person questionnaire is directed.

Design-builder #9

Honesty
Integrity
Character
Positive energy

Appendix N

ANOVA Tables and Multiple Range Test Tables for questions related to

Architectural Skills

Table 32

Analysis of Variance for Question 2: Ability to write/interpret specifications:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	10.55	5.28	2.92
Within Groups	174	314.71	1.81	
Total	176	325.26		

LSD test indicated no two groups are significantly different at the .05 level
(F Prob. =.0567)

Table 33

Analysis of Variance for Question 6: Ability to problem solve:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	1.81	0.91	2.19
Within Groups	177	73.05	0.41	
Total	179	74.86		

Table 34

Analysis of Variance for Question 7: Ability in graphic/hand communication:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	124.41	62.20	39.34
Within Groups	177	279.84	1.58	
Total	179	404.25		

$p < .001$

Table 35

Multiple Range Test for Question 7: Ability in graphic/hand communication:

Mean	Profession	Architects	Constructors	Design-builders
5.95	Architects		*	*
3.98	Constructors			
4.67	Design-builders		*	

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 36

Analysis of Variance for Question 10: Creative ability:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	25.34	12.67	12.13
Within Groups	177	184.97	1.05	
Total	179	210.31		

$p < .001$

Table 37

Multiple Range Test for Question 10: Creative ability:

Mean	Profession	Architects	Constructors	Design-builders
6.08	Architects		*	*
5.18	Constructors			
5.63	Design-builders		*	

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 38

Analysis of Variance for Question 11: Knowledge of use of materials and methods of construction:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	0.40	0.20	0.17
Within Groups	177	212.8	1.20	
Total	179	213.2		

LSD test indicated no two groups are significantly different at the .05 level
(F Prob. =.8456)

Table 39

Analysis of Variance for Question 12: Knowledge of local codes (building, planning):

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	2.86	1.43	0.66
Within Groups	177	385.34	2.18	
Total	179	388.20		

LSD test indicated no two groups are significantly different at the .05 level
(F Prob. =.5202)

Table 40

Analysis of Variance for Question 13: Ability to understand integration of systems:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	4.41	2.21	1.57
Within Groups	176	247.63	1.41	
Total	178	252.04		

LSD test indicated no two groups are significantly different at the .05 level
(F Prob. =.2113)

Table 41

Analysis of Variance for Question 15: Knowledge of Model Codes (BOCA, SBC, UBC):

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	8.35	4.17	2.50
Within Groups	177	295.4	1.67	
Total	179	303.75		

LSD test indicated no two groups are significantly different at the .05 level
(F Prob. =.0849)

Table 42

Analysis of Variance for Question 16: Ability to write/interpret contracts:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	100.87	50.44	22.78
Within Groups	175	387.49	2.21	
Total	177	488.36		

$p < .001$

Table 43

Multiple Range Test for Question 16: Ability to write/interpret contracts:

Mean	Profession	Architects	Constructors	Design-builders
3.48	Architects			
4.94	Constructors	*		
5.20	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 44

Analysis of Variance for Question 19: Knowledge of theory of architectural design and architectural history:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	146.65	73.33	37.94
Within Groups	176	340.18	1.93	
Total	178	486.83		

$p < .001$

Table 45

Multiple Range Test for Question 19: Knowledge of theory of architectural design and architectural history:

Mean	Profession	Architects	Constructors	Design-builders
4.90	Architects		*	*
2.91	Constructors			
3.11	Design-builders			

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 46

Analysis of Variance for Question 20: Ability to graphically solve problems:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	50.35	25.18	22.18
Within Groups	174	197.52	1.14	
Total	176	247.87		

$p < .001$

Table 47

Multiple Range Test for Question 20: Ability to graphically solve problems:

Mean	Profession	Architects	Constructors	Design-builders
6.02	Architects		*	*
4.94	Constructors			
4.85	Design-builders			

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 48

Analysis of Variance for Question 24: Ability to think spatially, in three dimensions:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	35.18	17.59	16.70
Within Groups	176	185.39	1.05	
Total	178	220.57		

$p < .001$

Table 49

Multiple Range Test for Question 24: Ability to think spatially, in three dimensions:

Mean	Profession	Architects	Constructors	Design-builders
6.52	Architects		*	*
5.55	Constructors			
5.65	Design-builders			

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 50

Analysis of Variance for Question 29: Knowledge of structural theory:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	27.75	13.88	7.57
Within Groups	176	322.49	1.83	
Total	178	350.24		

$p < .001$

Table 51

Multiple Range Test for Question 29: Knowledge of structural theory:

Mean	Profession	Architects	Constructors	Design-builders
5.10	Architects		*	*
4.31	Constructors			
4.22	Design-builders			

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 52

Analysis of Variance for Question 30: Ability to use CAD programs routinely (such as AutoCAD):

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	181.81	90.91	38.15
Within Groups	176	419.42	2.38	
Total	178	601.23		

$p < .001$

Table 53

Multiple Range Test for Question 30: Ability to use CAD programs routinely (such as AutoCAD):

Mean	Profession	Architects	Constructors	Design-builders
5.95	Architects		*	*
3.61	Constructors			*
4.22	Design-builders			

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Appendix O

ANOVA Tables and Multiple Range Test Tables for questions related to

Construction Management Skills

Table 54

Analysis of Variance for Question 3: Ability to do building layout on the site:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	0.72	0.36	0.13
Within Groups	175	480.18	2.74	
Total	177	480.90		

LSD test indicated no two groups are significantly different at the .05 level (F Prob. =.8770)

Table 55

Analysis of Variance for Question 14: Ability to perform value engineering or life cycle costs of a project:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	66.25	33.13	17.84
Within Groups	177	328.61	1.86	
Total	179	394.86		

$p < .001$

Table 56

Multiple Range Test for Question 14: Ability to perform value engineering or life cycle costs of a project:

Mean	Profession	Architects	Constructors	Design-builders
3.69	Architects			
4.62	Constructors	*		
5.19	Design-builders	*	*	

Mean is based on a 7 point Likert scale: 1 is not important. 7 is extremely important
* Indicates significant differences between groups

Table 57

Analysis of Variance for Question 18: Knowledge of safety laws (such as OSHA):

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	42.66	21.33	11.69
Within Groups	175	319.28	1.82	
Total	177	361.94		

$p < .001$

Table 58

Multiple Range Test for Question 18: Knowledge of safety laws (such as OSHA):

Mean	Profession	Architects	Constructors	Design-builders
3.77	Architects			
4.72	Constructors	*		
4.86	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 59

Analysis of Variance for Question 21: Ability to develop a simple schedule (such as a bar chart) for a project:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	40.56	20.28	12.45
Within Groups	175	285.13	1.63	
Total	177	325.69		

$p < .001$

Table 60

Multiple Range Test for Question 21: Ability to develop a simple schedule (such as a bar chart) for a project:

Mean	Profession	Architects	Constructors	Design-builders
4.93	Architects			
6.06	Constructors	*		
5.69	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 61

Analysis of Variance for Question 22: Ability to use computer software to generate sophisticated schedules (such as Primavera):

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	116.43	58.22	28.13
Within Groups	176	364.21	2.07	
Total	178	480.64		

$p < .001$

Table 62

Multiple Range Test for Question 22: Ability to use computer software to generate sophisticated schedules (such as Primavera):

Mean	Profession	Architects	Constructors	Design-builders
3.36	Architects			
5.16	Constructors	*		
4.93	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 63

Analysis of Variance for Question 23: Ability to estimate cost of structures:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	110.22	55.11	31.66
Within Groups	176	306.35	1.74	
Total	178	416.57		

$p < .001$

Table 64

Multiple Range Test for Question 23: Ability to estimate cost of structures:

Mean	Profession	Architects	Constructors	Design-builders
3.82	Architects			
5.50	Constructors	*		
5.44	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 65

Analysis of Variance for Question 27: Ability to use estimating software programs (such as Timberline):

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	114.35	57.17	29.02
Within Groups	176	346.77	1.97	
Total	178	461.12		

$p < .001$

Table 66

Multiple Range Test for Question 27: Ability to use estimating software programs (such as Timberline):

Mean	Profession	Architects	Constructors	Design-builders
3.25	Architects			
4.94	Constructors	*		
4.93	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 67

Analysis of Variance for Question 31: Ability to plan construction project execution (scheduling, resource leveling, site utilization):

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	173.58	86.79	52.78
Within Groups	176	289.41	1.64	
Total	178	462.99		

$p < .001$

Table 68

Multiple Range Test for Question 31: Ability to plan construction project execution (scheduling, resource leveling, site utilization):

Mean	Profession	Architects	Constructors	Design-builders
3.74	Architects			
5.86	Constructors	*		
5.76	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 69

Analysis of Variance for Question 32: Ability to monitor project costs:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	120.65	60.33	40.16
Within Groups	176	264.39	1.50	
Total	178	385.04		

$p < .001$

Table 70

Multiple Range Test for Question 32: Ability to monitor project costs:

Mean	Profession	Architects	Constructors	Design-builders
4.26	Architects			
5.94	Constructors	*		
6.06	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Appendix P

ANOVA Tables and Multiple Range Test Tables for questions related to

General Business Skills

Table 71

Analysis of Variance for Question 1: Ability to create, maintain and enhance effective working relationships.

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	0.15	0.07	0.08
Within Groups	176	175.21	1.00	
Total	178	175.36		

LSD test indicated no two groups are significantly different at the .05 level (F prob. = .9289)

Table 72

Analysis of Variance for Question 4: Adeptness as an entrepreneur:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	69.57	34.78	17.91
Within Groups	176	341.81	1.94	
Total	178	411.38		

$p < .001$

Table 73

Multiple Range Test for Question 4: Adeptness as an entrepreneur:

Mean	Profession	Architects	Constructors	Design-builders
3.30	Architects			
4.20	Constructors	*		
4.85	Design-builders	*	*	

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 74

Analysis of Variance for Question 5: Ability to use word-processors and spreadsheets routinely:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	18.29	9.14	5.98
Within Groups	176	269.26	1.53	
Total	178	287.55		

$p < .01$

Table 75

Multiple Range Test for Question 5: Ability to use word-processors and spreadsheets routinely:

Mean	Profession	Architects	Constructors	Design-builders
4.88	Architects			
5.51	Constructors	*		
5.61	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 76

Analysis of Variance for Question 8: Effectiveness in marketing and customer relations:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	35.31	17.66	9.28
Within Groups	176	334.67	1.90	
Total	178	369.98		

$p < .001$

Table 77

Multiple Range Test for Question 8: Effectiveness in marketing and customer relations:

Mean	Profession	Architects	Constructors	Design-builders
4.52	Architects			
4.95	Constructors			
5.63	Design-builders	*	*	

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 78

Analysis of Variance for Question 9: Effectiveness in written communication:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	1.92	0.96	1.10
Within Groups	177	155.08	0.88	
Total	179	157.00		

LSD test indicated no two groups are significantly different at the .05 level
(F prob. = .3358)

Table 79

Analysis of Variance for Question 17: Ability to generate business computer presentation using Powerpoint:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	22.24	11.12	4.84
Within Groups	175	401.85	2.30	
Total	177	424.09		

$p < .01$

Table 80

Multiple Range Test for Question 17: Ability to generate business computer presentation using Powerpoint:

Mean	Profession	Architects	Constructors	Design-builders
3.48	Architects			
3.58	Constructors			
4.30	Design-builders	*	*	

Mean is based on a 7 point Likert scale: 1 is not important. 7 is extremely important
* Indicates significant differences between groups

Table 81

Analysis of Variance for Question 25: Effectiveness in verbal communication:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	0.84	0.42	0.65
Within Groups	175	113.55	0.65	
Total	177	114.39		

LSD test indicated no two groups are significantly different at the .05 level
(F Prob. = .5265)

Table 82

Analysis of Variance for Question 26: Ability to use the Internet and e-mail routinely:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	12.47	6.24	2.95
Within Groups	176	372.01	2.11	
Total	178	384.48		

LSD test indicated no two groups are significantly different at the .05 level
(F prob. = .0550)

Table 83

Multiple Range Test for Question 26: Ability to use the Internet and e-mail routinely:

Mean	Profession	Architects	Constructors	Design-builders
4.61	Architects			
4.44	Constructors			
5.07	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Table 84

Analysis of Variance for Question 28: Knowledge of accounting and finance:

Variation Source	df	Sum of Squares	Mean of Squares	F
Between Groups	2	55.78	27.89	15.10
Within Groups	176	325.08	1.85	
Total	178	380.86		

$p < .001$

Table 85

Multiple Range Test for Question 28: Knowledge of accounting and finance:

Mean	Profession	Architects	Constructors	Design-builders
3.20	Architects			
4.41	Constructors	*		
4.33	Design-builders	*		

Mean is based on a 7 point Likert scale: 1 is not important, 7 is extremely important
* Indicates significant differences between groups

Appendix Q

Letter and Summary Data sent to Interested Respondent

CAL POLY
California Polytechnic State University
San Luis Obispo, CA 93407
California Center For Construction Education
Construction Management Department
(805) 756-1323 • Fax (805) 756-5740

March 12, 2000

Salutation
Address
City, State, Zip

Thank you for your participation in my research while attending Colorado State University. The study pertaining to differences among architects, constructors and design-builders concerning competencies and skills perceived as being important in newly hired graduates, is summarized and provided to you as you requested on the research questionnaire. Aided by your generous participation, the response rate was 56%, an excellent rate!

I trust you will find the information provoking and enlightening. I hope you will continue to support research examining the professions of architecture and construction which will improve higher education.

Sincerely,

Paul Weber
Co-investigator

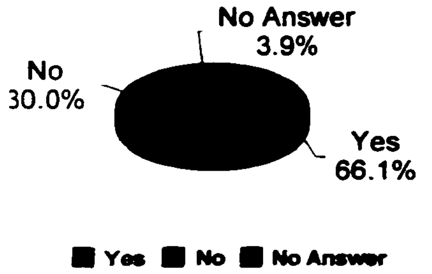
Paul A. Weber
Co-investigator, Ph.D. Candidate
Colorado State University
Fort Collins, Colorado
1999

REQUISITE SKILL DIFFERENCES OF BACCALAUREATE GRADUATES AMONG THREE BUILDING DISCIPLINES

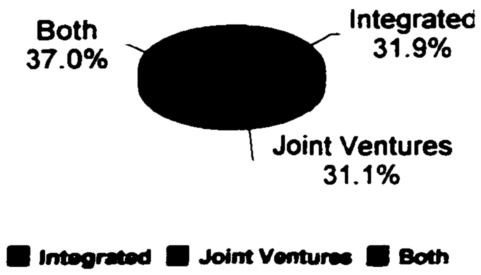
Summary of Data for Participants in the study

Demographic Information of participants. 324 Surveys, 180 returned = 56% response rate

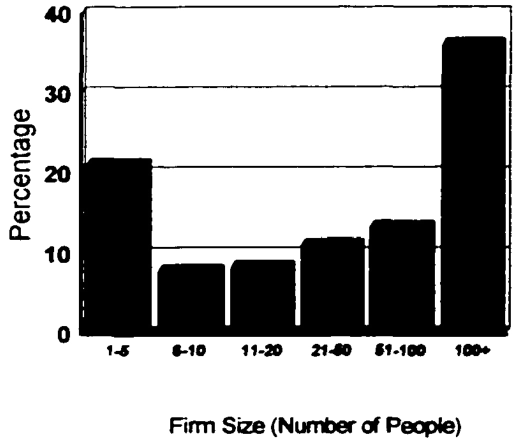
Participants	Frequency Response	Percentage	Cumulative Percent
Architects	61	33.9	33.9
Constructors	65	36.1	70
Design-builders	54	30	100
Total (N)	180		

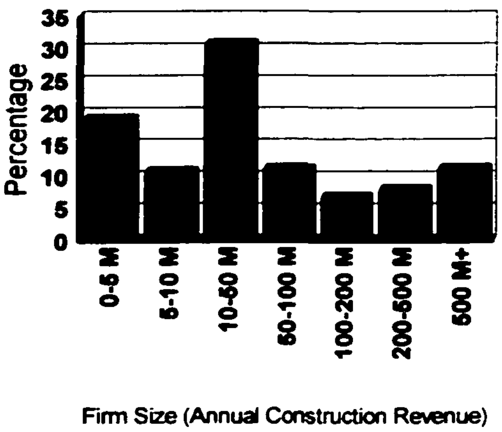


Involvement in Design-build



Structure of D/B Delivery





The following figures are grouped by those questions relating to architectural skills (Figure 1). construction management skills (Figure 2). and general business skills (Figure 3). The questions that were found to be statistically reliable and statistically significant are graphed.

The questions. rearranged by skill category. are as follows:

Architectural Skills:

Questions 2, 6, 7, 10, 11, 12, 13, 15, 16, 19, 20, 24, 29, and 30

Construction Management Skills:

Questions 3, 14, 18, 21, 22, 23, 27, 31, and 32

General Business Skills:

Questions 1, 4, 5, 8, 9, 17, 25, 26, and 28

The tables following the graphs summarizes the major findings of the study. Each question, under the column labeled Question, is repeated and the mean (average) score of the response from each discipline is shown under respectively labeled columns only where there is a statistically significant difference among the professions.

The questions were ranked by three types of professional. *Architects* (A). *Constructors* (C). and *Design-builders* (DB) utilizing a seven-point Likert scale where a score of 1 indicated "not important" and a score of 7 indicated "extremely important." The mean, standard deviation (how much each score deviates from the mean), and the valid number of responses are indicated under the column labeled *All Professions.*

The column labeled *Significance* indicates a difference relationship only with questions that indicated differences among the professions that were "statistically significant." Two questions, questions 3 and 16, were shown to be unreliable utilizing a statistical measure known as Chronbach's alpha, and are noted as unreliable. Only questions that had the statistical probability of not being true, by chance, less than 5% of the time (alpha level: $p<0.05$) were noted in the significance column (question 26 is close, at $P=0.0550$). The probability of making an error in stating there is a "significant difference" among the professions when there, in fact, is not a difference is noted under the column labeled *Statistical level F Prob.*

Where design-builders were significantly different than both constructors and architects (DB > A and/or C; A and/or C > DB), a remark for "future studies" was indicated in the *Remark* column. This study does not attempt to explain the difference, merely that one appears to exist. One conclusion, therefore, is a suggestion for future studies.

One example to help you interpret the results shown in the table below is question 4, Adeptness as an entrepreneur. The result indicated under the *Significance* and *Relationship* column indicates: DB > C > A. This means that the Design Builder's (DB) mean score of 4.85 is statistically significantly greater than the constructor's (C) mean score of 4.20 which, too, is statistically significantly greater than the mean score response of 3.30 from Architects (A). Conclusion: there are statistically significant differences among Architects, Constructors, and Design-builders in the importance of this skill. With a probability level of $p<.001$, this means there is a one in one-thousand chance that this hypothesis is in error.

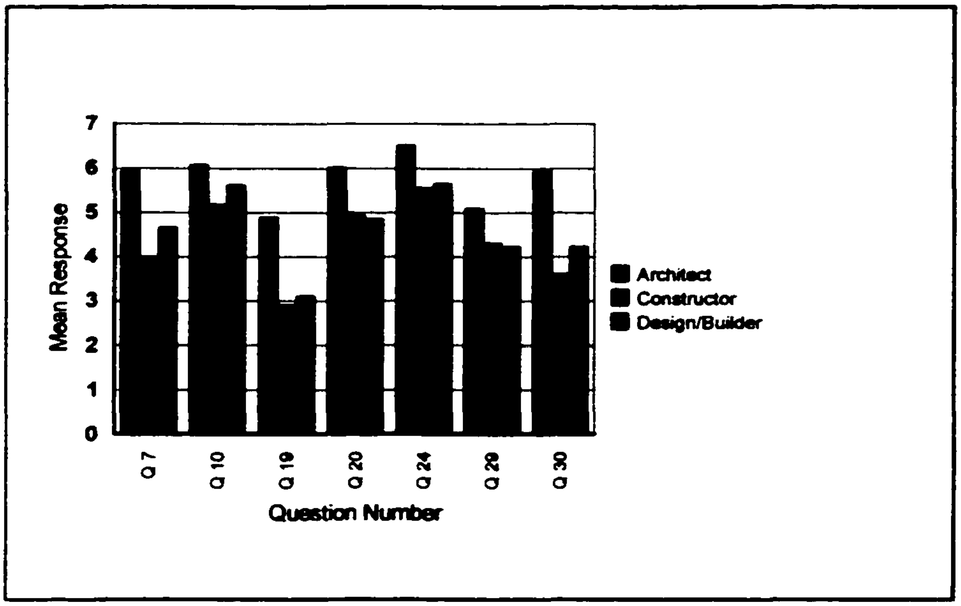


Figure 1. Mean Scores of the Questions Associated with Architectural Skills

Over half of the seven questions (questions 19, 20, 24, and 29) indicate that constructors and design-builders held similar views regarding the importance of these architectural skills.

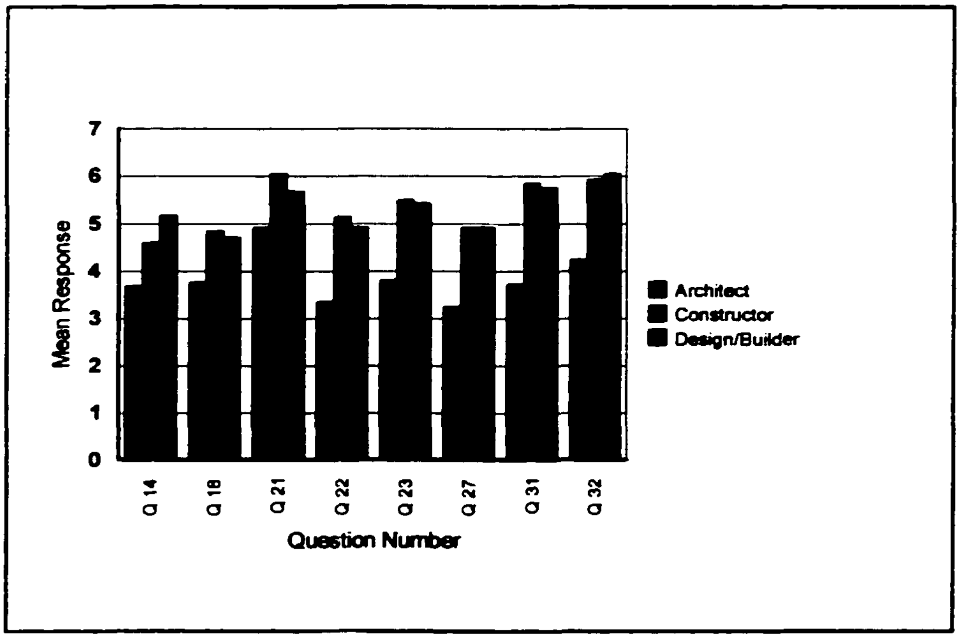


Figure 2. Mean Scores of the Questions Associated with Construction Skills

Seven of the eight questions (questions 18, 21, 22, 23, 27, 31, and 32) indicate that constructors and design-builders held similar views regarding the importance of these construction skills.

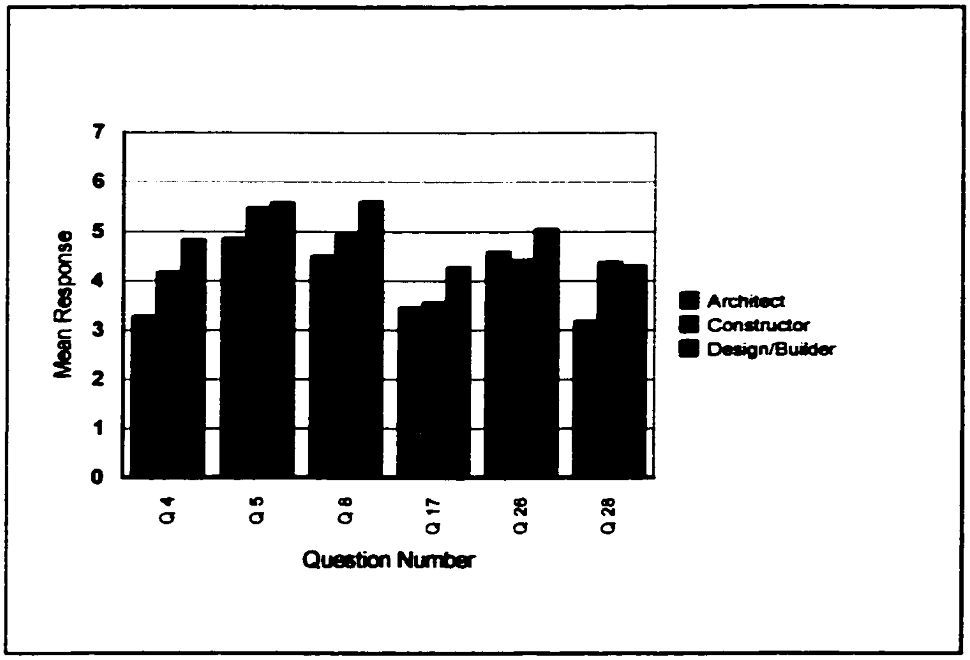


Figure 3. Mean Scores of the Questions Associated with General Business Skills

The results were mixed when comparing these six questions (questions 4, 5, 8, 17, 26, and 28) regarding the importance of general business skills among architects, constructors and design-builders. Design-builders rated the skill in question number four (adeptness as an entrepreneur), higher than that expressed by constructors, who in turn rated the skill higher than that expressed by architects. Design-builders rated the skill in question number eight (effectiveness in marketing and customer relations), higher than that expressed by constructors and architects. Design-builders rated the skill in question number seventeen (ability to generate business computer presentations using Powerpoint), higher than that expressed by constructors and architects. Design-builders rated the skill in question number twenty-six (ability to use the Internet and e-mail routinely), higher than that expressed by constructors. Design-builders were shown to rate that skill higher than architects, but it was not determined to be statistically significant. Design-builders and constructors rated the skill in question number five (ability to use word processors and spreadsheets routinely), higher than that expressed by and architects. Design-builders and constructors rated the skill in question number twenty-eight (knowledge of accounting and finance), higher than that expressed by and architects.

	Question	Architects (A)	Constructors (C)	Design Builders (DB)	All Professions			Significance		Remark
		Mean	Mean	Mean	Mean	Std. Dev	Valid N	Relationship	Statistical level F Prob.	
1	Ability to create, maintain and enhance effective working relationships:	6.17	6.23	6.22	6.21	0.99	179			
2	Ability to write/interpret specifications:	4.78	5.30	5.30	5.12	1.36	177			F prob.= .0567
3	Ability to do building layout on the site:	4.15	4.00	4.09	4.08	1.65	178			Question is unreliable
4	Adeptness as an entrepreneur:	3.30	4.20	4.85	4.10	1.52	179	DB > C > A	$p < .001$	Future studies
5	Ability to use word-processors and spreadsheets routinely:	4.88	5.51	5.61	5.33	1.27	179	DB and C > A	$p < .01$	
6	Ability to problem solve:	6.64	6.54	6.39	6.53	0.65	180			Note: High Score, low S.D.
7	Ability in graphic/hand communication:	5.95	3.98	4.67	4.86	1.50	180	A > DB > C	$p < .001$	Note: DB>C
8	Effectiveness in marketing and customer relations:	4.52	4.95	5.63	5.01	1.44	179	DB > A and C	$p < .001$	Future studies
9	Effectiveness in written communication:	5.70	5.85	5.96	5.83	0.94	180			
10	Creative ability:	6.08	5.18	5.63	5.62	1.08	180	A > DB > C	$p < .001$	Note: DB>C

	Question	Architects (A)	Constructors (C)	Design Builders (DB)	All Professions			Significance		Remark
		Mean	Mean	Mean	Mean	Std. Dev	Valid N	Relationship	Statistical level F Prob.	
11	Knowledge of use of materials and methods of construction:	5.66	5.60	5.54	5.60	1.09	180			
12	Knowledge of local codes (building, planning):	4.61	4.37	4.31	4.43	1.47	180			
13	Ability to understand integration of systems:	5.28	4.92	5.20	5.13	1.19	179			
14	Ability to perform value engineering or life cycle costs of a project:	3.69	4.62	5.19	4.47	1.49	180	DB > C > A	$p < .001$	Future studies
15	Knowledge of Model Codes (BOCA, SBC, UBC):	4.46	3.97	4.35	4.25	1.30	180			
16	Ability to write/interpret contracts:	3.49	4.94	5.20	4.53	1.66	178			Question is unreliable
17	Ability to generate business computer presentation using Powerpoint:	3.48	3.59	4.30	3.76	1.55	178	DB > A and C	$p < .01$	Future studies
18	Knowledge of safety laws (such as OSHA):	3.77	4.86	4.72	4.44	1.43	178	C and D/B > A	$p < .001$	

	Question	Architects (A)	Constructors (C)	Design Builders (DB)	All Professions			Significance		Remark
		Mean	Mean	Mean	Mean	Std. Dev	Valid N	Relationship	Statistical level F Prob.	
19	Knowledge of theory of architectural design and architectural history:	4.90	2.91	3.11	3.65	1.65	179	A > C and DB	p < .001	
20	Ability to graphically solve problems:	6.02	4.94	4.85	5.28	1.19	177	A > C and DB	p < .001	
21	Ability to develop a simple schedule (such as a bar chart) for a project:	4.93	6.06	5.69	5.57	1.36	178	C and DB > A	p < .001	
22	Ability to use computer software to generate sophisticated schedules (such as Primavera):	3.36	5.16	4.93	4.47	1.64	179	C and DB > A	p < .001	
23	Ability to estimate cost of structures:	3.82	5.50	5.44	4.91	1.53	179	DB and C> A	p < .001	
24	Ability to think spatially, in three dimensions:	6.52	5.55	5.65	5.91	1.11	179	A> C and DB	p < .001	
25	Effectiveness in verbal communication:	6.20	6.30	6.37	6.29	0.80	178			Note: High Score, low Std. Dev.
26	Ability to use the Internet and e-mail routinely:	4.61	4.44	5.07	4.69	1.47	179	DB > C	0.0550	Note: DB > C

	Question	Architects (A)	Constructors (C)	Design Builders (DB)	All Professions			Significance		Remark
		Mean	Mean	Mean	Mean	Std. Dev	Valid N	Relationship	Statistical level	
27	Ability to use estimating software programs (such as Timberline):	3.25	4.94	4.93	4.36	1.61	179	DB and C> A	$p < .001$	
28	Knowledge of accounting and finance:	3.20	4.41	4.33	3.97	1.46	179	DB and C> A	$p < .001$	
29	Knowledge of structural theory:	5.10	4.31	4.22	4.55	1.40	179	A> DB and C	$p < .001$	
30	Ability to use CAD programs routinely (such as AutoCAD):	5.95	3.61	4.22	4.59	1.84	179	A > DB > C	$p < .001$	Note: DB > C
31	Ability to plan construction project execution: (scheduling, resource leveling, site utilization)	3.74	5.86	5.76	5.11	1.61	179	C and DB > A	$p < .001$	
32	Ability to monitor project costs:	4.26	5.94	6.06	5.40	1.47	179	DB and C > A	$p < .001$	
SS1	Architecture/Engineering skills: 10, 24, 6, 19, 29, 11, 13, 15, 12, 2, 16, 20, 7, 30	5.54	4.71	4.88	5.04	0.78	180	A> DB and C	$p < .001$	
SS2	Construction skills: 31, 23, 27, 21, 22, 32, 14, 3, 18	3.85	5.36	5.34	4.84	1.19	180	DB and C > A	$p < .001$	
SS3	General Business skills: 25, 9, 1, 8, 4, 5, 17, 26, 28	4.67	5.06	5.37	5.02	0.80	180	DB > C > A	$p < .001$	Future studies

Appendix R

Cost of Survey

Cost of Survey

Item	Count	Cost per Unit	Cost
MTCM Envelopes	347	Free	
Return envelopes	347	Free	
MTCM Letterhead	347	Free	
Copies of questionnaire			$42.80
Postage of 1st mailing	328	$0.32	$104.96
Copies of follow-up post card			$6.92
Cutting the postcards from 8-1/2" x 11" stock			$4.00
Mailing of postcards	328	$0.20	$65.60
Postage of 2nd mailing (requests after follow-up)	19	$0.33	$6.27
Reimburse MTCM Department for returns	182	$0.14	$24.57
Subtotal			**$255.12**
Cost per questionnaire			*$0.78*
Cost for inputting statistics @ $25/hr			$54.75
Cost for running statistics @ $35/hr			$105.00
Subtotal			**$159.75**
Cost per questionnaire			*$0.49*
Cost for phoning none respondents			
February Long Distance charges			$3.92
March Long Distance charges			$42.14
Subtotal			**$46.06**
Cost per questionnaire			*$0.14*
Cost of mailing results to interested participants			
Cal Poly Envelopes	142	Free	
Cal Poly Letterhead	142	Free	
Copies of results			$7.00
Mailing the results			$46.86
Subtotal			**$53.86**
TOTAL COST			**$514.79**
Total cost per questionnaire			*$1.57*