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Comparative characteristic and performance analyses of on-campus engineering graduate students to off-campus engineering graduate students enrolled in non-tutored courses offered via videotape.

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COMPARATIVE CHARACTERISTIC AND PERFORMANCE ANALYSES OF ON-CAMPUS ENGINEERING GRADUATE STUDENTS TO OFF-CAMPUS ENGINEERING GRADUATE STUDENTS ENROLLED IN NON-TUTORED COURSES OFFERED VIA VIDEOTAPE

A Dissertation Presented

by

HARVEY RICHARD STONE

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
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School of Education

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DEDICATION

To those who matter and taught me the most...

My parents, Charlotte and Lou, who always believed...

Faith, my wife and teacher, whose benign neglect turned first to wonder and then to enthusiastic support...

My children, Heather Naomi and Nicholas Lee, for their limitless love and bewilderment with "Daddy's book"...

This dissertation is lovingly dedicated to all of you. Thank you for helping me in letting "the arrow fly" and allowing me to "go beyond"...

HRS

May, 1986

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ABSTRACT

COMPARATIVE CHARACTERISTIC AND PERFORMANCE ANALYSES
OF ON-CAMPUS ENGINEERING GRADUATE STUDENTS
TO OFF-CAMPUS ENGINEERING GRADUATE STUDENTS ENROLLED
IN NON-TUTORED COURSES OFFERED VIA VIDEOTAPE

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The purpose of this inquiry has been to determine the efficacy of video-based instruction for off-campus graduate students in engineering.

While literature supports use of local tutors and class-size sufficient to promote local dialogue, developments in telecommunications, expansion of available courseware, and need for flexibilities in scheduling combine to increase instances of students studying singularly or in very small groups. This study was aimed at determining whether tutor support could be withdrawn without significant loss in performance, as the researcher hypothesized.

To test the hypothesis, research and control samples were created from on and off-campus engineering graduate students in the University of Massachusetts' Departments of Electrical and Computer Engineering and Industrial Engineering/Operations Research enrolled from the Fall 1980 through Spring 1985 semesters. Two groups of students were removed from the sample. The first consisted of students graduating from foreign undergraduate institutions. The second group included those who registered but withdrew from courses prior to receiving a grade. The resulting sample totaled 1,028 which was subdivided into six program areas: on-campus Electrical and Computer Engineering (ECE) ($\underline{n}$=219); off-campus ECE degree ($\underline{n}$=84); off-campus ECE non-degree ($\underline{n}$=424); on-campus Industrial Engineering/Operations

Research (IEOR) ($\underline{n}$=83), off-campus IEOR degree ($\underline{n}$=66); and off-campus IEOR non-degree ($\underline{n}$=152).

To determine significant characteristics within each group, statistical tests were run to determine relationships between performance (graduate QPA) and six variables including: chronological and degree age, scores on the GRE Verbal, Quantitative, and Analytic tests, and undergraduate quality point average. Further, on-campus characteristics were compared to those for off-campus students using the same variables.

To assess variation between on and off-campus performance, off-campus graduate QPA's were compared to predictive levels established by on-campus students. Further, course-sections were identified in which at least two on and two off-campus degree students were enrolled. Analyses of variance were then run to determine whether significant performance differences existed between the two groups.

Major descriptive findings for ECE included no main effects in graduate performance and GRE Quantitative and Analytic test scores. Significant variation existed for chronological and degree age, GRE Verbal, and undergraduate QPA. In the IEOR sample, significant differences were not

found for graduate performance and GRE Verbal, Quantitative, and Analytic test scores. Significant variation was noted between groups for age, degree age, and undergraduate QPA. Analyses of variance for off-campus ECE performance against on-campus predictors offered no main effect. Significant variation was found between on and off-campus IEOR student. However, variation between the curricula available to the two groups discounts this finding. In 36 ECE courses meeting the study's criteria, grades in only one showed significant variation between on and off-campus degree students. In none of the 17 IEOR courses was significant grade difference found.

Major conclusions include: (1) that significant differences do not exist between on-campus students studying traditionally and off-campus students in non-tutored videotape classes, (2) that off-campus students learn as well as their on-campus colleagues and (3) that non-tutored video instruction is as effective as its tutored cousin. This augers well for the continued development and utilization of telecommunications technology to meet individual off-campus student needs.

Follow-up research should include further analysis of performance factors affecting off-campus non-degree students. Both ECE and IEOR non-degree students performed

at lower levels than on and off-campus degree students. The current study was limited to conjecture as to why, since available data were limited to graduate QPA and age (which proved to be insignificant). A second issue that warrants further probe is related to factors leading to substantial attrition among off-campus non-degree students. In ECE, 50% of non-degree students withdrew from the program (and were excluded from the study). In IEOR, over 30% of students were excluded for the same reason.

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The Setting

> Technical talent is the raw material that feeds the growth of high technology industry, and we have reason to be concerned about the adequacy of our supply. There is a serious shortage of engineers in America which limits the depth and breadth of product and technology development we can under take. Underlying this shortage is an underfunded and overstretched system of education.
>
> Global Stakes[(1)]

Contemporary American higher education is acknowledged as serving society in a number of ways. Contributing to the knowledge base and the preparation of a knowledgeable citizenry are two roles that generate little argument. Yet, from its earliest history, America's colleges and universities have also served as incubators for those entering the nation's professions. (2) Here the tradition is extraordinarily rich and the evolutionary trail unbroken. From the creation of Harvard College in 1636 "to set the world straight", (3) through the passage of the first Morrill Act in 1862, acknowledging "that a new age required new training and new preparation", (4) to the present, the symbiotic relationship between higher education and professions has rarely been questioned.

This interface, long assumed in disciplines such as law and medicine, is now being articulated throughout much of the "high technology" engineering and computer industries. Where previously, education's role as an important resource for "raw materials" had been relegated to a minor position, the shift to a "knowledge intensive society" has altered the balance. "For the first time in history, the link between higher education and high technology has become direct-so direct that when higher education falters, high tech can falter." (5) This perspective is fully supported by the Aerospace Industries Association of America which acknowledges that "(e)conomists have found that the relationship between basic or applied research/development and productivity and economic growth is strong and positive...Over the long term, national economic and productivity growth depend heavily upon the kind of basic research performed largely at universities." (6)

The AIAA offered the following graphic to illustrate its position. (7)

A CONCEPTUAL MODEL OF THE LINKAGES IN THE R&D PROCESS AND THEIR BENEFITS TO INDUSTRY, SOCIETY AND THE ECONOMY

Benefits to Industry

Basic Research:

Provides store of knowledge and new ideas for future development and innovating technology.

Reduces the cost of applied research and development

Applied Research:

Directs research towards practical application.

High rate of return on industrial research and development outlays.

Development:

Refines application of technology into products which will satisfy known needs at competitive prices.

Final Sales:

Disseminate information about products to the end user.

Provide rate of return sufficient to finance continued research and development and sales.

Benefits to Society and the Economy

Basic Research:

Improves our understanding of our surroundings.

Applied Research:

Practical technology often forms the basis for innovations outside the industry.

Development:

Adapts known technology to meet consumer needs at reasonable prices.

Final Sales:

Offer consumers a choice of useful products at competitive prices.

Price-competitive US-made products promote domestic and economic growth, and balance of payments, and price stability.

Following traditional supply/demand models, colleges and universities have endeavored to meet marketplace needs. Students, responding to employment opportunities cyclicaly gravitate from one field of study to another. Post-secondary institutions, responding to changing demands, will to a greater or lesser extent depending upon local considerations, expand in certain areas while de-emphasizing efforts in others. Tenure and labor/management issues aside, this scenario works best in disciplines where faculty resources are readily available and needs for capital investment and specialized equipment are minimal.

A classic example of program expansion to meet student demand is the explosive growth in legal education experienced throughout the United States during the 1960's-1970's. Demand was easily met. Faculty with sufficient credentials were plentiful and, other than library facilities, little more was required than a building to house instructional operations.

The same cannot be said for the nation's engineering schools and colleges working to satiate industry's deepening appetite for computer engineers and scientists. Faculty are at a premium. Curricula are under tremendous pressure to keep pace with emerging technologies. Aging physical plants are strained to accommodate rapidly expanding student populations and demands of increasingly sophisticated equipment. Laboratory equipment and computing power, baseline prerequisites in engineering education, are increasingly expensive and prone to rapid obsolescence. To illustrate, the National Association of State Universities and Land-Grant Colleges recently calculated the average cost for equipment per undergraduate FTE to be $901 for the 1984-1985 academic year. This represented a 252% increase over 1980-1981. The average equipment budget for a college of engineering increased 230% during the same period, from $529,000 to $1,748,000. (8)

While America's engineering education establishment is facing its own crisis of major proportions, the nation's industrial sector demands not only increasing number of young graduates, but support for the renewal of current employees. Howard Foley, of the Massachusetts High Technology Council, offered one perspective on this problem.

> While engineering schools are struggling to stay on top of their traditional roles of undergraduate and graduate education, a new reality is emerging with potentially revolutionary impact--namely, the intensifying need for continuous lifelong education. The accelerating rate of knowledge generation and technology change, quickly obsolesce the knowledge base of many of our working technologists and university faculty.
>
> Universities are now faced with the prospect of educating technologists not just once, but two or three times during their working lifetimes. This new reality isn't just coming--it's here now. (9)

Foley's concerns with lifelong engineering education, were echoed by Professors Fano, Bruce, Siebert, and Smullen, authors of MIT's widely distributed "Report of the Centennial Study Committee." The MIT committee argued:

> The future vitality and competitiveness of U.S. high technology industry depend on widespread acceptance of lifelong formal education activities as integral components of productive engineering work. This is so because:
>
>> The present rapid rate of scientific and technical innovation invalidates one of the basic assumptions underlying the traditional structure of engineering education: that a few years of formal education can provide an adequate foundation for a lifetime of professional engineering work.
>>
>> The demand for highly creative up-to-date engineers has intensified during the last decade as a result of the rapid growth of the knowledge-intensive industry and of the increasing competition for national and international markets.
>>
>> This demand cannot be met by replacing "obsolescent" engineers with new graduates (and the human costs of such a replacement policy would be unacceptable even if it were feasible).
>>
>> The only apparent alternative is better utilization of the presently available engineering workforce through continuing education at the workplace, with the active support and encouragement of employers. (10)

These statements and their associated issues provide the framework for a problem facing, with equal import, American high technology industry and American engineering education. Given burgeoning industrial and defense-related needs for products of higher education, and further given the limited ability of the educational system to respond adequately, methods must be identified that increase academia's productivity. By definition, this assumes that current industrial demands will not substantially diminish in the near term and that the precarious position currently faced throughout much of engineering higher education will continue at least moderately unabated throughout the same period.

To truly appreciate the problem's scope and importance, factors leading to and resultants of engineering's supply/demand imbalance must be recognized. An awareness of this setting quickly shows the importance of determining those effective methods allowing increased faculty productivity in manners that do not compromise traditional on-campus priorities. The following brief analysis of manpower issues currently facing the nations high technology R & D and manufacturing sectors place this paper's research in its proper context. The balance of this chapter will offer an overview of current issues in engineering manpower and the crisis currently experienced throughout engineering higher education.

Overview of Issues in High Tech Engineering Manpower

Demand Factors

> Again and again, my Japanese friends pointed out what they consider to be the basic difference in the way that Japan and the US discern opportunities: "You in the United States have in the last ten years doubled the number of people in law schools, while you barely even maintained the number of people in engineering schools. We in Japan have not increased the number of lawyers but have doubled the number of engineering students. Lawyers are concerned with dividing the pie, engineers are concerned with making it larger." (11)

One of the common perceptions within the high technology community, is that the need for electrical and computer engineers and computer scientists greatly exceeds their available supply. Industrial anxiety is heightened by projections that note that this gap will continue through the foreseeable future. An analysis conducted by the American Electronics Association (AEA) provides oft-quoted grist for high tech's mill. The AEA offered the following:

TABLE #1
U.S. Electronics Industries
Comparison of Projected Supply and Demand
Electrical and Computer Engineers

(12)

YEAR	DEMAND (1,000's)	SUPPLY (1,000's)
1981	29.5	12.8
1982	33.8	13.2
1983	38.9	13.8
1984	44.7	14.1
1985	51.3	15.0

Although this particular survey has undergone critical scrutiny, (13) and its conclusions questioned, (14)(15) its message has been positively received throughout much of industry and engineering higher education. Further, the demand for technical manpower can only increase as products from the microelectronics and computer revolutions broadly spread to secondary and tertiary users throughout industry. No longer are computer and microelectronics corporations sole consumers of computer and high tech engineering talent. (16) Rather, all of American industry must be considered as it takes "user-based" advantage of the technological explosion. Indeed, manufacturing engineers, historically relegated to backwashes of the engineering profession, are now, as firms increase productivity and quality through use of computer-based numerical control machines and robots, assuming roles of increased importance and visibility. This trend can only be heightened as major manufacturing industries further the process of "'concurrent engineering', manufacturing engineers work(ing) as a team to coordinate product design between the product engineer and the manufacturing support group." (17)

Stephen Kahne, of the National Science Foundation, argues in support of this position:

> It is no longer an open question whether the shortage of electrical engineers in the United States is or is not a crisis: it is. Sooner or later, every U.S. industry dependent on electrical engineering will be affected-and there are more such industries now than ever. Indeed . . . new industries, previously unaffected by electrical engineering in any significant way, are the hidden factor that invalidates traditional market needs for electronic specialists in sectors of the economy that never before employed them. (18)

Accepting the assertion of a gap between supply and demand, what might be some of the factors leading to this imbalance? Clearly, Kahne's argument has merit. Demands for higher productivity and quality control/assurance inexorably lead to increased incorporation of electronics into the workplace. Not only is manpower required to design and develop increasingly subminiaturized and multi-functional components but also to effectively integrate these products into the manufacturing process and user-based goods.

Federal budget priorities also effect both the degree and direction of the engineering manpower shortage. A strong economy coupled with high levels of defense expenditures will continue to deepen the demand on high tech talent by drawing many from the private sector to defense-related projects. In an NSF-sponsored study conducted during the Carter Administration, data indicate that largest manpower imbalances would occur during periods of "accelerated defense spending." It further noted that even during normal periods, computer professionals and industrial engineers would continue in short supply. (19) This places the United States at a continuing disadvantage to Japan. On a per capita basis, the Japanese have allocated a negligible proportion of its high technology manpower to defense-related research and development. In America, some have estimated that the proportion of electronic engineers devoted to this effort totals 50%. (20) This is particularly problemmatic. On one hand, as Botkin and others have argued, their is little beneficial spinoff from defense developments to the commercial sector. Such efforts serve to "sidetrack commercial efforts by setting R & D standards that are not compatible with industrial needs." (21)

For example, note the development by the Defense Department of its Very High Speed Integrated Circuit (VHSIC) computer architecture which competes with the private sector's VLSI (Very Large Scale Integrated Circuit) architecture technologies. VHSIC's development has a negative impact upon the private-sector as "(c)ontractors and subcontractors alike expect to switch their best engineering talent to the VHSIC project as it requires the most advanced skills. This might not itself represent much of a problem, except as there is some question as to the commercial impact of military research. The most immediate impact will be to leave potentially large vacuums in non-military research efforts, especially at highly experienced scientific levels. Yet it is precisely those skilled, mature engineers who are most difficult to find and that industry needs most." (22)

The VHSIC/VLSI rivalry for skilled manpower is a classic but by no means exceptional example of the public/private competition for skilled engineers and computer scientists. In a 1981 issue of "Fortune Magazine," the chief of Rockwell International's (a major defense contractor) aircraft group was quoted as having "identified 5,500 Rockwell employees he could strip out from other assignments . . . while he could recruit 11,000 more from outside the company." (23)

Competition between defense and the private-sector for highly skilled personnel is a traditional instance of insufficient resources being chased by growing demands. What is novel, is the form taken by the needed commodity. Historically, capital, machinery, fossil fuels, and the like have been considered crucial to manufacturing process. Today, highly trained people are considered basic. This is well-recognized concept in Japan where MITI (Japan's Ministry of International Trade and Industry) has pronounced that "it is extremely important for Japan to make the most of her brain resources, which may well be called the nation's only resource." (24)

Botkin, writing in Global Stakes, set forth America's version of this maxim.

> The fact that high technology products embody an unprecedented amount of human knowledge and technically sophisticated labor will change the equations by which national priorities are calculated. Whereas American wealth and power have traditionally been based on natural resources and on capital investment in physical plant and machinery, the balance is now tipping toward investment in people and knowledge as key resources. (25)

Exacerbating supply problem's are disturbing trends that find many engineers eyeing positions in management as key indicators of personnel success. The prevailing cultural bias notes that "no one wants to be a fifty year-old engineer." (26) Schmaling has commented:

> The managers of technically-based industry are generally drawn from the most technically productive engineers. These engineers become managers, are peers of the older engineers they have "passed-by." In many cases, the managers feel that the older engineers are correctly pidgeonholed. The oft repeated statement, "If you haven't made it by 40, you won't," is a reflection of this culture. (27)

These positions are supported by Levy (28) and Jones (29) whose data indicate that a key objective for engineers participating in continuing education was the pursuit of alternate career opportunities, namely management.

With the current U. S. political environment signalling that defense-related research and development will continue to escalate, with private-sector R & D continuing unabated on multiple fronts, and given broadening integration of high technology's products into manufacturing activities, it seems unlikely that demand for skilled engineers and engineering-related professionals will diminish.

The factors detailed above, which foster the need for increased supplies of technical talent and augment the need for continuing and lifelong engineering education posit substantial pressures upon the traditional supply system. The remainder of this chapter will highlight the system's ability to respond in the traditional mode.

Supply Capabilities of Engineering Higher Education

Expanding the Pipeline

> The modern world is becoming increasingly dependent on technological systems of growing complexity. At the same time, the intellectual and material bases for the design and fabrication of such systems are in a state of rapid evolution. Computers represent an obvious example of such important, complex, rapidly evolving systems, but they are by no means unique; the phenomenon pervades virtually every branch of technology.
>
> One inevitable consequence of this trend is the expanding worldwide demand for individuals with appropriate technological training. In the United States this problem is particularly acute; indeed many observers have characterized it as a "crisis." Rapid expansion of the numbers of U.S.-trained engineers will not be easy, however. Our engineering-education "plant" is relatively small and under-equipped . .

> . . Substantial increases in the numbers of U.S. graduate engineers--however desirable--simply cannot be accomplished soon; filling the pipeline and building the necessary educational infrastructure will take the better part of a generation.
>
> (30)
> Report of the Centennial Study Committee
> Massachusetts Institute of Technology
> 1982

Although engineering higher education is one of many factors contributing to high technology's perceived manpower imbalance, it is a primary focus of industry's concern. The quality and quantity of higher education's product links to the growing currency that people, rather than minerals and machines, are high technology's most crucial resource. It follows that "(h)igher education is an enterprise of rising importance (to high technology). Conventional thinking had "education play(ing) a relatively minor role. But in terms of the shift toward knowledge industry, education takes on strategic importance." (31)

Members of the high technology community, sensitive to this symbiotic relationship, would well quake in their collective I/O ports were they to survey the current state of engineering higher education throughout the United States. (32) A vicious cycle is working. Fed by industry's appetite for the BSE graduate, it has been compared to "starving American Indians of long ago who, to survive the winter, ate the seed corn needed to plant next year's crop." (33)

The process begins with the high demand for engineering baccalaureates, which concomitantly reduces the number of individuals who might normally pursue graduate education. Decreased graduate enrollment yields commensurate reductions in doctoral production inevitably resulting in fewer available faculty replacements. The circle is completed with a reduced capacity to produce future B. S. graduates.

With the explosive expansion of technological research and developments in manufacturing, and parallel requirements for personnel, high technology industries compete for resources with an "open market" mentality. They traditionally seek young engineers to their employ by offering higher and higher starting salaries. According to the College Placement Council, the average annual salary offered to engineering baccaluareates in 1984 is $26,276. Computer scientists could anticipate an average starting salary of $24,552. (34)

While this statistic may offer welcome news to new engineering and computer science graduates, its long run impact is to wreak havoc throughout engineering higher education. As starting salaries continue to escalate the number of B. S. graduates willing to pursue graduate study suffers. In 1976, approximately 4.25% of engineering baccalaureates continued toward the Master's Degree. By 1980, this ratio fell 15% to 3.6%. (35)

Referring specifically to this problem, Dr. Lionel Baldwin, President of the National Technological University and former Dean of Engineering at Colorado State University noted:

> Record numbers of students are graduating from baccalaureate engineering and computer science programs. Overwhelmingly, these young graduates are choosing to enter US industry without advanced or specialized study, although by academic ability, at least two thirds of the B.S. graduates today could profit from further formal study.
>
> This downward trend is not likely to change in the forseeable future for several reasons: the lure of high wages for B.S. graduates; burn-out after 4 years of intense study; and lack of insight in to what specialization would be most useful on the job. (36)

While John's recent survey of NASULGC (National Association of State University and Land-Grant Colleges) institutions offers evidence of an increase in graduate engineering enrollment, (37) hoped-for relief in engineering's faculty shortages is offset by the 1982 data indicating only 17% of engineering doctoral students intending higher education as a career. This is a drop of 32% since 1960. (38)

The perception of low initial incomes and lower than average rates of growth provided disincentives to the prospective graduate student considering a career in higher education. (39)(40)(41) Now, however, NASULGC reports indicate that current salaries, when combined with summer compensation, offer incomes competitive to those offered by industry. (42) However, many concerned with faculty recruitment now cite new impediments, "the decrease in the attractiveness and the quality of the university environment as perceived by . . . prospective faculty. This makes the task of attracting even a portion of the best engineer(ing) students to an academic career very difficult. This perceived degradation of the engineering academic environment comes about because of heavy teaching loads, antiquated and inadequate equipment and declining technical and staff support services." (43) In 1975-1976, 7,724 faculty taught and supervised 135,506 engineering graduate and undergraduate students. By the 1981-1982 academic year, faculty ranks recorded an increase of barely 10% while enrollment soared two and one half times. (44) This problem is particularly acute in departments of electrical and computer engineering. John reported evidence that enrollment rose 22% while faculty size in the same institutions grew by only 8.3%. (45) In these same state and land-grant institutions, faculty to grad student ratios now average an increase of 19% from 1982-1983 through 1984-1985. (46)

Taking together the concerns of time for preparation (and its loss of income), lower starting salaries, shallower salary growth curves, and diminished research capabilities and support, few should be surprised at the ratio of U.S.-born engineering graduate students to their foreign-born counterparts. Currently, only 65% of all engineering graduate students are American citizens. (47) Both the American Society for Engineering Education and the Congressional Research Service have identified the increased presence of non-American-born graduates as worsening the current manpower imbalances in U.S. industry and higher education. (48)

While the graduate student problem is a mid-range issue, the supply/demand imbalance in engineering faculty ranks is one currently being felt. Basically, there are more faculty positions open then there are people to fill them. A 1982 report noted that 8.5% of authorized faculty slots in electrical and computer engineering were unfilled. In departments of computer engineering and computer science, vacancies rose to 17%. (49)

Struggling under the inability to reduce the financial gap between what faculty can earn in higher education as opposed to their colleagues in industry (50) and education's diminished research role due to obsolescing physical plants and equipment (51) coupled with the major expense required just to keep equipment up-to-date, (52) it should not be surprising to note that 61.2% of institutions surveyed reported either a moderate or substantial decrease in their abilities to retain or recruit faculty. (53)

These shortfalls have resulted in measurable and negative impacts research and instructional activities. According to a 1980 survey by the American Council on Education, only 5.8% of engineering institutions surveyed "reported that they had experienced no significant effects due to their inability to hire full time faculty." (54) The results of this survey are noted in TABLE #2.

TABLE #2
EFFECT OF INABILITY TO RECRUIT AND RETAIN FACULTY

Effect	Public Schools	Private Schools	All Schools
Reduction in Research	33.7%	29.7%	32.5%

Increase in Teaching Load	75.9%	59.5%	70.8%
Greater Reliance on Teaching Assistants or Part-Time Faculty	75.9%	62.2%	71.7%
Course not Offered	47.0%	48.6%	47.5%
No Significant Effect	4.8%	8.1%	5.8%

Summary

Statement of the Problem

> If what we want are more senior engineers, we should turn more to those who already exist. Increasingly, the supply of new engineering graduates-even if it occurs quickly, which it most likely will not-will continue to advanced or senior levels only after seven to ten years. In the meantime, many senior engineers are exiting the profession for management and other career paths that are more rewarding . . . . It seems that nobody wants to be a fifty-year old engineer in America, but America needs all of them desperately . . . . An important goal of lifelong learning should be to elevate the professional status of the engineer in industry (and) to increase the viability of engineering as a lifelong career . . . . Technical obsolescence is certainly one of the problems that older engineers face as bright young graduates come out of universities steeped in the latest technology. Obsolescence is exacerbated by the fact that the complexity of modern technology increasingly obliges individuals to specialize narrowly to be successful in their organization. When a new wave of technology breaks, which occurs now with increasing frequency, the worth of an engineer's prior experience is substantially devalued, or at least it is perceived that way. In reality, the mature judgement, depth of knowledge, and

> organizational experience of mature engineers are invaluable assets. A greater commitment to lifelong learning by companies (and universities) can circumvent or at least greatly ameliorate the issue of technical obsolescence. (55)

Faced with their own diminished resources, America's higher education establishment is increasingly unable to support industry's demand for increasing numbers of young graduates and support of lifelong engineering education. Engineering education's capacity is already at the limit. Confronted with burgeoning on-campus time demands, few institutions are easily able to satisfy off-campus industrial need for continuing engineering education in the traditional mode of having resident faculty either teaching in the evening or traveling to offer their courses at remote locations. There are just not enough engineering faculty to do justice to both tasks. Required are technological tools that allows instructional productivity to be raised in a manner that enables faculty to serve off-campus populations without diminishing on-campus efforts. As the National Academy of Engineering wishfully noted, "If new technologies can somehow permit handling larger number of students with the current number of faculty and, of course with no loss of quality, then an increase in the engineering doctoral output would not be needed." (56)

Instructional television (ITV), is one approach that fosters increased faculty productivity. ITV allows a broader dissemination of faculty's instruction to large and small pockets of employees widely scattered throughout industry, without a parallel drain on faculty time and effort. Using televised instruction, faculty are able to offer instruction to great numbers of students at disparate locations, at one time, without having to travel. ITV, and specifically its "candid classroom" format, offer real economies of scale. MIT's Centennial Report aptly lays out the problem and indeed offers ITV as a viable method of reaching desired goals.

> The scale and diversity of the off-campus educational program that we envision require other departures from traditional modes of instruction . . . . To start with, most classes will likely be quite small, with perhaps as few as half a dozen students. This is because there are many work locations with small engineering staffs, out of which only a few people are likely to be interested in attending the same class . . . . Furthermore, classes would have to be scheduled to meet local desires and constraints . . . . Thus is would be difficult to coordinate classes covering the same subject matter at different location, if the coordination must take place primarily through the class instructors.
>
> Clearly we must depart from the traditional format of instruction based on relatively large classes and rigid schedules. We must also be able to utilize instructors with much less expertise in the subject matter

> being covered than is necessary in the traditional instruction format.
>
> Fortunately, there is more than ten years' experience with remote teaching using films, TV broadcasting, and videotapes. The techniques of videotaping formal lectures in a studio, and of recording live classes without destroying their spontaneity are by now well developed. They have proven to be economical and educationally effective ways of eliminating the need for live lectures by experts. (57)

While the utilization of instructional television (ITV) to promote education and training is drawing increasing support, ITV has long been present as a tool within higher education. It surfaced as early as the 1950's with Carpenter's efforts at Penn State where he videotaped classes and made them available to students for later viewing on a flexible schedule. (58) As hardware became less expensive and easier to use, its usage grew to the point where now ITV in support of instruction, both on and off-campus and both for credit and professional development has become common. Dirr, in a 1978 survey of 3,000 colleges and universities noted the use of instructional television in over 70% of his sample, with 66% of this group using television for instructional purposes. (59)

The Association for Media Based Continuing Education for Engineers (AMCEE), (60) a consortium now numbering 33 schools of engineering throughout the nation has, through 1980, enrolled over 30,000 engineers in more than 1,200 non-credit continuing education courses. (61) In a more recent survey, Baldwin and Down (62) noted that that through 1982, 25 schools and colleges of engineering had offered nearly 800 video-based non-credit courses to over 50,000 engineers at more than 2,700 corporate facilities.

The development and acceptance of credit courses and graduate degree programs offered over ITV has evidenced equally impressive growth. Baldwin and Down note that in 1967, graduate ITV enrollment was already estimated at 4,000, with students able to choose from slightly under 200 courses. By 1979, enrollment exceeded 44,000 students who were able to access 1,800 courses offered by 30 colleges and universities. Through 1982, over 3,500 Master's Degrees were awarded to individuals whose primary mode of off-campus instruction was instructional television. (63)

Regardless of its growth, the validity of ITV as an instructional tool is questioned. Though antagonists may agree that it is useful for broad dissemination of information, they regard ITV's ability to deal with individual concerns and feedback as fatal. Waniewicz (64) summarized the argument.

> (T)he learner cannot be left alone in the process of learning, In the majority of cases he needs supervision, guidance, additional clarification of the information he receives; he needs exercise, verification of results achieved at particular stages and so on. The media cannot by themselves provide for this. In order to consolidate and extend their impact, they have to be accompanied by support and follow-up devices of one form or another. They have to be woven into a system, which will provide the human contacts necessary in education.
>
> Without especially devised feedback mechanisms the educator cannot know who actually receives the message, or how they react to it . . . . (TV) does not provide for resolving misunderstandings which may appear in the process of delivering information; it cannot answer questions that are not anticipated before the transmission of the programme. It cannot supervise students' activities, nor control and verify progress made by them. Because it is aimed usually at large audiences, the pace of instruction, the gradation of difficult material, the amount of material delivered in one programme unit must take into consideration the abilities of the average student. In other words, broadcasting cannot take care of the individual needs of the student.

In response to the concern that "the major weaknesses of . . . 'television' are all related to the fact that it cannot provide the quality of personal interaction among both students and faculty that is available in an effective classroom," (65) selected members of the faculty and administration of Stanford University's School of Engineering developed a program designed to maximize interaction while maintaining the flexibility inherent in videotaped instruction. (66) Cognizant of the fact that relatively unstructured videotape instructional programs could not assure sufficient feedback and individualization, Stanford integrated a system of tutor in its video instructional program. This effort, known as TVI (Tutored Video Instruction), is viewed as a national model. It is grounded on the "common sense notion that students can learn more from a lecture if they are free to interrupt it at places where they need more discussion or explanation of a point or concept (and that students will learn best) when the videotaped lectures are stopped frequently (with such frequency and duration that are impractical in a traditional classroom environment)." (67)

> The TVI technique responds to the educational needs of the students by combining the positive features of lectures with those of small group discussion in which the lectures are used directly to provide the basis for discussion. The lectures provide the depth and continuity in the subject matter, while the tutorial discussions provide a means for making the lectures respond to individual needs and differences.
>
> Students watching the videotaped lectures feel free to ask questions to both the tutor and other students, and to make spontaneous comments about points of interest in the lecture. In addition, since the video tapes are of an actual classroom, the TVI students hear all of the comments and questions asked in class and

> profit from these exchanges as well. In effect, the TVI format permits the students and the tutor to manage the lecture themselves, and thereby create an intellectually stimulating environment which enhances learning and creates a positive attitude toward both the subject matter and the group. (68)

Tutors participating in the TVI Program are selected by Stanford faculty from practicing line engineers already employed at remote locations. They are not selected for their content expertise. Nor are they required to grade examinations or correct homework assignments. Their criteria for selection are: sensitivity to students; ability to draw students into discussion; and a personal interest in the subject matter. Recent exposure to the subject matter or past participation in the course itself was not found to be an important value. Tutors are to: "1) initiate and encourage the stopping of tape for immediate resolution of problems . . . 2) answer questions that could not be resolved by the class itself . . . (and) 3) obtain supplementary materials from the on-campus instructional staff." (69) In addition to on-site activities, tutors are expected to meet with Stanford's instructional staff at least twice each quarter to work to resolve problems that may arise throughout the course. Commenting on the use of tutors, MIT's Myron Tribus noted that tutors are not to supplant the faculty. Rather, their prime function is to "enhance and extend the lectures by giving examples from daily work. Better yet, the tutor can help the students develop their own examples . . . . The task of particularizing the material is not left with the professor . . . . The local tutor plays more the role of consultant than the role of professor." (70)

While the tutor's instructional role has been emphasized, a key function is to offer structure to an otherwise overly flexible learning environment. In off-campus videotape or ITFS instructional programs that have not incorporated tutors (which comprise the vast majority of programs), individual students are primarily responsible for scheduling, viewing, and keeping pace with on-campus colleagues. In certain instances, participating employers serve in this role. However, under normal circumstances, the individual is unsupervised. As a result, there are few mechanisms in place that can "prod the laggard". In those instances where students have come together to view tapes and study in groups, peer group coherency may develop to offer mutual structural support.

If stopping tapes, promoting discussion, and answering questions are beneficial structural indicators, then tutors are filling an important role. (71) In the Stanford TVI Program, tapes were stopped an average of 1.8 times per instructional session with 77% of "stops" initiated by tutor/facilitators. Remote students sought out tutors (outside of class) for questions an average of 8.6 times per course. (72) These statistics are far in excess of the anecdotal evidence expressed by coordinators of programs without the benefit of tutors.

While tutored video instruction has a number of obvious advantages over non-tutored external videotaped or ITFS engineering programs, and its efficacy as an instructional tool has been validated (see Chapter 2), its use is the exception rather than the rule. In the majority of instances, students are left on their own to determine whether or not to stop lectures, replay confusing segments, ask questions among themselves, and relate the lecture's theories to local application. Further, students must schedule viewing times on their own, be responsible for their own attendance, and develop liaison with on-campus faculty and support services. Such program's conflict with Gibbons and others who declare that ITV's effectiveness requires immediate and directed feedback to students. As a result, much of ITV's effectiveness as a teaching tool falls suspect.

Advances in technology allowing broader dissemination of instructional material to small pockets of remote students in fact makes the installation of tutorial support programs more difficult. As costs come down for course delivery, technical advances will enable colleges and universities to cost-effectively, offer courses to single individuals at remote locations throughout the country at one time. While technology drives down costs for course delivery it cannot similarly reduce costs associated with local tutorial support. Participating employers will find themselves both unwilling and unable to offer tutors for the myriad courses from which their employees will be able to choose. As a result, off-campus students will more often than not, find themselves on their own or in very small groups.

This phenomenon is already observed both in traditional videotape instructional programs (unsupported by tutors) and by enrollment characteristics experienced by the National Technological University. The average viewing group is very small. In the Videotape Instructional Program offered through the University of Massachusetts' College of Engineering, recent data indicated an average of fewer than 2.25 viewers per course per location. (Gibbons notes that at least 3 students are required. Lacking that number, "effective interaction is lacking and the method tends to be expensive.) This results from the fact that institutions are now able to offer a wide number of courses giving students a broad choice. As ability to select increases, the number choosing individual courses diminishes. Hence, the size of the viewing group in reduced.

The problem is complicated by the flexibility required by employee students in viewing. Varying work and travel schedules often necessitate individuals viewing on their own schedules. This often results in students studying on their own. Those enrolled in courses available through the National Technological University's real-time satellite delivery program, normally request their companies to tape courses when they are transmitted for later viewing. Therefore, the ability of the technology to allow a high degree of flexibility actually retards those structures which may support "learning" and promotes unstructured, study-on-your-own programming.

While published studies (see Chapter 2) show performance (as measured by grades) of off-campus graduate students participating in tutor-supported videotaped engineering courses to be comparable and by certain criteria better than their counterparts enrolled in the same courses on-campus, little has been done to support a similar contention in off-campus video courses unsupported by tutors. As a result, much of ITV's use in off-campus engineering education falls suspect.

The following study seeks to close this gap in our information base. It will test relevant hypotheses that seek to affirm the contention that off-campus performance does not suffer when tutors are not present and that off-campus grades will compare favorably to those earned by on-campus engineering graduate students. Further, it identifies those quantifiable differences between off-campus students studying in a non-tutored videotape program and their peers on-campus as well as those quantitative characteristics that impact upon performance (as measured by grades). Specifically, the research will test the null-hypotheses that quantitative admissions criteria (age at time of enrollment, degree-age at time of enrollment, scores of the Graduate Record Examinations Verbal, Quantitative, and Analytic tests, and undergraduate grade point average) have no relevance on graduate performance as measured by the graduate grade point average. To prove these null-hypotheses, the variables noted above will be tested against on and off-campus (video) students enrolled in the University of Massachsuetts' departments of Electrical and Computer Engineering and Industrial Engineering/Operations Research.

Assuming the resulting analyses support the contention that off-campus,non-tutored, video viewers perform as well on-campus graduate students, than this form of continuing engineering education is a valid approach for use by colleges and universities as they work to meet industrial demand for instructional services. Hence, the broad continuing training and education needs of professional needs can to a great degree be met without a substantial drain on local faculty resources. The data will also advise faculty and employers as to those student characteristics most likely to indicate success among the many who will participate in video engineering programs.

Lastly, as the use of satellite-delivered education grows beyond its now narrow parameters, the results provided might well be transferable to technical fields beyond engineering.

CHAPTER 2

Instructional Television in Engineering Education

A Review of the Literature

> There can no longer be any real doubt that children and adults learn a great amount from instructional television. . . The effectiveness of television has now been demonstrated in many parts of the world, in developing as well as in industrialized countries, at every level from preschool through adult education, and with a great variety of subject matter and method. (73)

The following chapter will offer a selected review of the literature concerned with the adoption, use, and effectiveness of instructional television in support of higher engineering education. It will begin with an overview of those factors impacting upon the adoption by faculty of ITV in support of instruction. Highlighted issues will include hardware and software concerns, a discussion of those instances allowing for the effective and efficient utilization of television, and general faculty self-perception regarding the use of video.

From the issue of adoption, the discussion will move to an analysis of that form of instructional television most prevalent throughout engineering higher education, the "candid classroom". Research will be offered to support the overall contention that the media's "simple" use results in effective delivery of education and contradict the position that education can only occur through the use of exotic, time-consuming, and expensive production techniques.

The candid classroom as a delivery facility will then be described including an analysis of its design as a direct result of its function. Included in this section will be references to operations, student acceptance, and on-campus applications.

The chapter will conclude with research highlights detailing studies designed to measure the performance of students learning via ITV as compared to those enrolled in traditional "live classes".

As a teaching tool, television is not a new phenomenon. "Captain Kangaroo," "Sunrise Semester," and Bishop Sheen's "Life is Worth Living" long preceded "NOVA," "Sesame Street," and "The World of Jacques Cousteau" are examples of broadcast media' use to enlighten and entertain. The nation's Armed Forces have used television for years in training its personnel.

Instructional television, long promised as a panacea allowing more to be better served at less expense, has experienced slower than expected rates of growth and acceptance. Hardware availability is not the issue. Rather, impediments exist at the interface between man and machine. Missing is the educational "software" and "system-wide" commitments required for ITV's successful integration at appropriate points in the educational environment. As such, its slow development closely parallels experiences faced by institutions of higher education working to integrate "the computer" throughout their curricula. In his study on the relationship of technology to quality in engineering education, Jones contended that hardware advances will outdistance those in software. "For educational institutions, this probably means that significant investments in the creation of useful software will be essential . . . ." (74)

Baldwin and Down, writing for the National Academy of Engineering also noted the problem.

> The promise of technology in the educational process at all levels has never been greater than it is today. The reason is clear: the microelectronics revolution of the past decade, together with digital and laser system development, is just starting to bear fruit in useful instructional hardware. The cost of such

> hardware continues to decrease and may soon be an insignificant development. Now the challenge of devising appropriate ways to employ hardware in education is brought into sharper focus.
>
> For a variety of reasons however, the practice of ET falls short of the promises envisioned by some people. Cost is often sighted as an impediment . . . . Yet, economically attractive alternatives such as some forms of instructional television (ITV) have not gained universal acceptance . . . . Lack of wide acceptance of ET is sometimes traced to conservative institutions of higher education in which, it is argued, neither faculty nor administrators have the appropriate experience and knowledge needed to introduce ET effectively. (75)

While myriad issues slow the widespread advance of instructional television, not the least of which is the concern that effective classroom instruction often benefits from capitalizing on unexpected occurrences and opportunities, certain problems immediately come to the fore. The first is the lack of a clear understanding of what ITV can and cannot do.

Use of mass media does not automatically result in mass learning. Television offers no quick solution for problem in education's dissemination. Users of television as an educational delivery mechanism need to appreciate that "messages" simply cannot be injected into learners via ITV any more than they might in the traditional classroom settings This "hypodermic" approach must be discarded and replaced with an accepted understanding that "mass media messages interact with an individual's characteristics to create an effect. . . . Likewise (practitioners) must move away from the belief that the simple use of televised material of some sort will lead to effective and efficient learning . . . . (R)esearch indicates that effective and efficient learning from television is the result of a carefully planned process which begins with an understanding of the characteristics and needs of particular learners and then examines the factors which influence how particular learners can best learn from television." (76)

In support of this "systems approach" to the effective utilization of instructional television, Gibbons synthesised guidelines to be followed: (77)

1. The education program should be planned for a specific target audience.

2. Specific educational objectives that are relevant to the needs and interests of the target audience must be clearly defined.

3. Technologies should be chosen in terms of the topic to be presented. Frequently, different technologies are used to present different parts of a course, the choice being determined by

a consideration of which technology is most effective for the material being presented.

4. Educators who have a clear interest in learning and using the instructional characteristics of various media must be selected and trained.

5. Clear and careful provision for personal interaction is important for retention on student interest.

6. Evaluation and feedback over a period of months of years must be used to monitor the educational effectiveness of the program and to change instructional materials and methods to suit learner needs.

Good educational process is good educational process regardless of where it is practiced. The use of ITV, in and of itself, is neither necessary nor sufficient for good or improved learning. It is solely a tool. Instructional television must be viewed as no more than one weapon in an arsenal able to come to bear where and when its integration is indicated. ITV, as part of a mix, works best "when it is made an integral part of instruction-that is, when it is woven in a . . . context of learning activities . . . . (78) As Knepper noted, "the mere adoption of a technology-based instructional approach does nothing to guarantee that effective transfer will occur." (79) Rather "the particular 'who' wished to reach should be a primary determinent of the particular use to which ITV is put." (80) While television has been shown to be an effective teaching tool throughout the world, at all age groups, "nowhere had television been utilized effectively for instructional purposes alone or without a variety of differentiated support systems for different clients under differing circumstances." (81)

Instructional television is not all things for all people at all times nor will it replace the traditional classroom teacher. Indeed, research indicates that "even the most nominal person-to-person contact is the critical element in the successful utilization of ETV . . . . (Some form of human contact is) critical to student involvement, student retention, student perseverance, and student achievement." (82)

In his review of the literature, Shanks summarizes ITV's most "effective and efficient roles." (83)

> Television is most effective when it is used as part of a mix of relevant materials; such a mix usually includes some personal contact with an instructor or with some other content expert (e.g. a tutor).
>
> Television is most efficient when it is designed to reach large audiences.
>
> Television can be efficient and effective if a truly excellent teacher, better than those usually available is made available to large numbers of people.

> Television is effective if the broadcast is prepared with more care, time, and effort than a regular classroom teacher could afford to devote to the lesson.
>
> Television is effective if the broadcast uses materials, evidence and demonstrations which can explain the problem better than those which are usually used in classrooms.
>
> Television is effective because it can choose the best way to convey information: narration, dialogue, lecture, discussion, interview, commentary, dramatization, scenes shot on location, simulations, demonstrations, etc.

A second factor retarding wider use of instructional television, with particular emphasis in higher education, is that the change process (adoption of the innovation) is itself slow. While traditional culture offers a picture of academia as fermenter of change and challenger of accepted order, reality offers an alternate perspective. As Evans, who studied early attempts to incorporate ITV into the practice and culture of higher education declared:

> The greatest resistance to change will be found in those institutions whose traditional primary function has been the perpetuation of society's folkways, mores, and values, such as religious and educational institutions. Paradoxically, the common assumption is that educational institutions, since they are charged with imparting both old and new knowledge to the young, must themselves be highly dynamic, with frequent changes in teaching methods as well as content. Furthermore, the

> assumption is that teachers and school administrators are such highly specialized experts in evaluating new developments in their field that from the many innovations offered, they will carefully choose those which seem to provide the greatest potential for teaching.
>
> Past studies in innovation in education have found little empirical evidence to support the above assumptions. (84)

Factors further slowing the adoption of ITV were identified by McCosh who surveyed 135 departments of accounting. (85) McCosh noted that impediments included: student complaints that ITV was too impersonal; faculty perceptions that ITV did not further education; administratives concern about a lack of suitable facilities; and faculty's sense of not being adequately rewarded, not given publication credit, and not allowed released time to appropriately develop courses.

There is little doubt that faculty self perception has played a major role in slowing the adoption process. Few consider teaching via television as part of their ethos. (86) While most in Evans' sample indicated that "good teaching" was an important component in their role, fully 40% viewed content competency as sufficient towards this end. Only 35% thought that teaching methodology held some importance. (87) He was repeatedly told that quality instruction "involves more than just transmission of information" and that this extra ingredient "is present in the more traditional teaching methods, but lacking in ITV . . . ." (88) However, when queried as to what these extra ingredients might be, faculty became ambiguous. This lead Evans to assume that "less intellectual factors played a greater role" in resistance to innovation than were being openly admitted. (89)

Evans found that faculty's "general reluctance to desert tried and true teaching methods, along with his firm belief that only through personal contact can the student be properly motivated, predict his reluctance to accept ITV as a vehicle for teaching." (90) Further digging into faculty resistance Evans noted that faculty were concerned that others would see just how they taught; that controversial remarks would "come back to haunt them"; and that in the extreme, useage of ITV would result in faculty layoffs. Evans noted: (91)

> A professor . . . might become convinced that television lectures would reduce his teaching time, but he would still oppose ITV because of the greater difficulty of teaching through the medium. Some felt that without feedback from students, controversial viewpoints expressed by the teacher might be misinterpreted . . . .

> While some . . . admitted that ITV is economical, effective, and efficient, they felt that an instructor might be justified in fearing it as an innovation which might even lead to widespread unemployment of classroom teachers.

Evans concluded that while faculty argued that ITV diminished academic quality, led to mediocrity, and was of little use as demonstrated by the fact that elite institutions were not using it, (92) many were really fearful of going before the camera. (93) In effect, faculty were implicitly stating that they were threatened by the technology.

Indeed, this is a prime concern that must be addressed before any expect widespread adoption of the use of ITV or other technologies within the realm of higher education.

The "Candid Classroom": An Effective Instructional Tool

This study will evaluate data obtained from the non-interactive "candid classroom" variant of instructional television. Some definitions and distinctions are now in order. Caution is required. While delineations offered are necessarily bi-polar, readers should recognize that programming output is on a continuum and definitional separations are often blurred in practice. With this caveat in mind, the first order is to distinguish instructional television (ITV) from educational television (ETV). Robert Dean, former Director of Extended Engineering Education at the Georgia Institute of Technology suggests the following division:

> Instructional television (ITV) differs from educational television (ETV) in that ITV infers direct use of television in the instructional process while ETV uses television programs as an instructional supplement in much the same way as you would use a movie in a classroom. (94)

In the candid classroom format, "production values" are often narrow and "pretty pictures" (beyond a base level) are rarely considered necessary. Programs can be created quickly and with relatively little expense. This is normally a requirement. Speed and ease are required given the minimal faculty time available, the need to reproduce tapes quickly so that they may be shipped on a tight schedule, and the economic reality that in engineering, given the dynamic state of the field, taped materials have a relatively short "shelf-life". This differs substantially from productions of lower level courses and those developed by the British Open University. In those instances, instructors are often assigned to produce a specific televised course as opposed to the American system where taping occurs on the margin of faculty time. In "lower level" courses, where subject matter does not undergo rapid and dramatic change, additional time and expense can be spent with the expectation and understanding that the course will be shown to a wide audience over a long period of time.

ITV productions are designed as a direct part of the educational experience. This is also reflective of the market each is designed to serve. The ITV market is normally smaller than that associated with ETV programming but with deeper content-oriented requirements. The ETV program viewer is often a member of a broader market whose objectives are more diffuse and content-shallow. An additional distinction is that ITV participants often take more active roles in the viewing process while the ETV audience is more passive. In bringing these together, "NOVA," "Sesame Street," and "The World of Jacques Cousteau" although are at the ETV end of the spectrum. A videotaped short course in computer architecture, or programs offered for academic credit in a "candid classroom" mode are at the other.

The ITV format most often used in engineering higher education, and the focus of this effort's study, is "candid classroom". It is an approach to instructional television primarily concerned with replicating classroom activities. Its successful recognizes that television exists to support the faculty in the normal course of instruction rather than requiring faculty to conform to production constraints. As a result, "candid classroom" operations interpose few if any limitations on "talent".

This philosophy acknowledges that faculty participate voluntarily. Were instructors forced to conform to production concerns, few would offer their services. From a production persepctive, candid classroom operators have learned to be satisfied if faculty began classes by reviewing what they did "last time", previewed what they will do "today", do it, and conclude by summarizing what was taught and highlighting what will be offered "next time". This approach to ITV should prove "to be a medium . . . friendly to traditional stand-up teaching and not require extensive development time . . . common with other delivery systems." (95)

A candid classroom studio facility is not an "origination site for polished TV productions--instead, it focuses on the predefined educational outcomes and uses video to electronically extend the classroom walls." (96) Ideally, the facility is transparent to in-class activities and designs and activities have evolved in recognition of this reality. Compare the following to traditional television studios, equipped with heavy mobile cameras, operators, producers and directors supervising the operators, and glaring klieg lights.

> The candid classroom, as opposed to a television studio, maintains the traditional classroom motif. Whereas the studio has a proliferation of cameras, lights, cables, microphones, and other paraphenalia plus the technical team that is required to produce a polished production, the candid classroom minimizes the distractions of equipment and production teams. <u>The studio environment would not be conducive to ITV as the equipment and people would distract from the instructional process if the production involved both teachers and students as performers.</u> Therefore, the candid classroom generally has the television cameras and other apparatus placed in unobtrusive locations and operated by remote control from outside the classroom. In the candid classroom, both the professor's lecture and, if appropriate, the student's discussion are recorded or broadcast without the distractions generally associated with a studio environment. (97)

Critics of this utilitarian ethos argue that educational products resulting from this approach have little educational efficacy. However, researchers continually discern that fancy pictures and high cost productions are not requisite for delivering quality education. Indeed, two factors identified as leading to ITV ineffectiveness are an over-reliance upon hardware and programs "planned by media experts who do not have the requisite training in learner characteristics and methodologies for affacting content instruction." (98)

Schramm, one of the field's seminal researchers, supports the contention that simplicity can result effective educational delivery. He argues that production considerations should not be inserted into educational programs unless they are directly related to the subject under discussion. For instance, if color is crucial to the program's subject matter, courses should be taped in color. If color is not required as part of the course's content, its singular presence does not enhance learning. Schramm's findings include the following: (99)

> Color seems not to increase learning unless color is what is to be learned or unless it is the best means available to code some discriminations that are to be learned.
>
> A big screen seems to be of no advantage to learning if the ordinary television screen can be seen clearly enough to pick out the details that are being learned.

Students like a "talkback" system but seem to learn no more with it than without it.

Visual embellishments do not usually help learning unless (like directional arrows) they can help organize content that is not well organized or (like animation) helps viewers to understand a process or concept that is very hard to understand without such simplification. In other words, visual embellishments per se are not especially useful in instructional material.

No advantage has been demonstrated for existing three-dimensional projection.

No learning advantage has been demonstrated for "professional" or "artistic" production techniques.

Eye contact seems not to contribute to learning, although it may contribute to persuasion.

There is very little evidence that narrative presentation ordinarily has learning advantage over expository or that adding humor adds to learning effect.

<u>Remember that we are talking about learning, not liking. Some of these complexities may cause a student to like a program better, and in special cases any of the special treatments we have mentioned may contribute also to learning. But for the most part, the research encourages us toward a simple rather complex or fancy style.</u>

At least two straightforward guidelines standout from the research papers we have reviewed. <u>Effective television can be kept as simple as possible, except where some complexity is clearly required for one task or another; students will learn more if they are kept actively participating in the learning process. Simple television: active students.</u>

Schramm's positions are reinforced by Shanks' recent survey. In identifying those factors that most influence learning from media, Shanks discerned that faculty rather than technology had a greater impact on learning. (100) These included: having the lectures placed in their proper context; structuring lectures so as students are alerted to important information during the lecture; being considerate of the presence of "remote students"; and bringing relevant examples to bear in support of theory. Again, good teaching begets good learning.

Operationally, students participating in candid classroom-based graduate engineering programs are normally held to levels of quantity and quality similar to those established for their on-campus colleagues. Off-campus video participants are usually considered "regular" graduate students and viewed as part of the "day" FTE population. "This integration of ITV students into the regular campus programs contrasts sharply with the traditional evening programs of metropolitan universities or extension division offerings." (101) Normally, "evening programs" make extensive use of adjunct faculty selected from neighboring industry and offer watered-down and unaccredited alternatives to "day" curricula. In most engineering ITV activities, off-campus students gain from exposure to the same graduate-level faculty and accredited programs that are available on-campus. They receive the same degree awarded their on-campus counter-parts. (102)

In tape delivery systems, faculty teach their normal course before on-campus students. At the end of each day or week, tapes, handouts, assignments, and examinations are duplicated and shipped to program coordinators at industrial sites. These individuals then arrange for viewing by employees and, when required, monitor examinations. When laboratory equipment or computer access is required, they are provided by the employer.

Although viewing schedules are flexible, ITV engineering programs are not study-on-your-own-schedule activities. Off-campus students normally start shortly after on-campus classes begin and are expected to end within one to two weeks on the on-campus semester. (103)

Taped courses are not edited, allowing off-campus participants benefit from the question and answer interplay between faculty and students in the on-campus classroom. If remote students have questions that cannot be resolved through internal discussion or by stopping, rewinding, and repeating segments of the tape, faculty have reserved telephone office hours to respond to questions from the field. During the next taping session, faculty will often repeat the most commonly asked questions and answer them for everyone's benefit. With the advent of electronic mail and similar computer-based conferencing systems, faculty will be able to respond to student queries on a more immediate basis and disseminate the responses throughout the network.

The description offered above has focussed on one-way, non-interactive education delivered by videotape through instructional television's candid classroom format. A variant of this approach is found in those systems "broadcasting" using microwave or ITFS (Instructional Television Fixed Service-short range, low power, directed television transmission) facilities. In these instances, courses are available to industrial students in real-time and, through audio return (often using telephones), participants can "talk back" to the faculty.

Many extol the benefits of talkback systems. However in practice, they fall short of expectations. "Talkback" requires students to be present at receiving sites at the same time the course is offered on-campus. Thus, in order to take advantage of the direct feed-back loop, off-site students, for example, would have to be available three times-a-week, from 9:00 AM to 9:50 AM.

Six disadvantages arise from use of talkback systems. First, involvement is limited to students working for companies willing to adopt released or "flex time" policies allowing employees to attend classes during working hours. The second is that real-time requirements drastically reduce the viewing flexibility that many feel desirable. Third, viewers lose the ability to stop, rewind, and replay unclear portions of lectures on an as-needed basis or to stop tapes to foster discussion among viewers. Fourth, with no tapes, no resources are kept on-hand for later review. (104) Fifth, equipment required to support interactivity is often more expensive and complicated than is required in simple playback situations.

The last disadvantage relates directly to the real-time requirement inherent in interactive systems. As early as 1971, program administrators at Lawrence Livermore Laboratories, who had implemented an interactive system, noted high drop-out rates among their participating engineers. Attrition approached 50%. After reviewing the local situation, it became apparent to Livermore officials that employees withdrew most often due to work-related time pressures rather than course content. For instance, employment-related travel requirements made it difficult or impossible for engineers to "keep-up". When the Livermore program moved to a non-interactive videotape format, not only did the drop-out rate decrease to 10%, but the level of participation increased five fold. (105)

Experiences in those "talk back systems" that have been operating for a period of time, such as Southern Methodist University (TAGER System) and Stanford, report a frequency and quality of faculty/student interaction at less then hoped-for levels. A recent internal study at Southern Methodist indicated, after all ITFS courses were monitored over a period of one semester, that less than one question per class session was offered using the network. These included questions asked "out" by faculty as well as question raised by students. SMU statistics also noted that administrative questions ("When will the homework be returned?", "Please keep the display on the screen longer.") were raised with equal regularity to those concerned with course content. (106) At Stanford, Lemon reported recently that, on average, talkback was used rarely more than once every other class session. She noted that the system's use or lack thereof was a direct function of the faculty. Students were more apt to use the system if faculty established the precedant and maintained the practice. (107)

While there is a divergence of opinion on real-time interactive systems versus "bicycling" of videotapes, the flexibility and simplicity of the latter seems to offer an overall advantage. Rogers, of Case Western Reserve University, noted that his institution moved from broadcast to videotape at the request of the program's corporate clients. Now a proponent of the videotape-delivery system, he offers the following: (108)

> As the tapes become more widely used, two features connected with their use became widely evident. First, the stop, rewind and freeze frame capacities of the playback device contribute to the students ability to learn from videotapes, by allowing replay of any segment and freezing of any display. Second, the student in the same class who view the tapes in groups help each other by clarifying and explaining points in the lectures and discussions. Interrupting and instructor's live lectures can have undesirable consequences which do not accompany interrupting a videotape of the same lecture. Furthermore, there are limits to both the number of interruptions, and to the duration of any one interruption, which an instructor can tolerate in a live class. These limits are far less stringent when a small group is watching a videotape.

Rogers also offered the following as a rationale for his position.

TABLE #3
COMPARISON OF VIDEOTAPE VERSUS BROADCAST SYSTEMS

PROBLEM	BROADCAST SYSTEM (With Direct Telephone Back to Classroom)	VIDEOTAPE (With Freeze Frame Pause Control
Schedule Conflicts:		
The student is out of town and misses a class.	The student misses the class.	The student views the tape when he returns.
The student is sent to the field or is transferred to a new job.	The student misses the class and may have to drop the course.	Tapes are shipped to the new location.
Pedagogical Difficulties:		
Student watching alone wants clarification on a point.	Student phones in and interrupts the class.	Student stops and replays the tape or calls faculty during office hours.
Students in a group want clarification on a point.	Same as above.	Same as above as well as talking to group members.
Procedural Requests:		
Students want material held on the screen until it can be copied.	Student calls, interrupts the class, and asks faculty to to hold material on the screen longer.	Students use PAUSE button and screen is frozen.

Applications of Instructional Television in Engineering Education

Use of ITV in support of engineering education is undergoing rapid expansion. In most instances, researchers have noted that participating students, both on and off-campus learn as well or better than their peers in traditional classroom modes; on-campus students will choose traditional lectures over those that are media-assisted; and faculty will often tend toward stand-up lecturing rather than ITV regardless of derived benefits.

On the other hand, as ITV gains footholds throughout traditional academia, more will be drawn to its use as it allows traditionally busy faculty to do what they want to do more easily and quickly. Jones (109) briefly highlights the implications for teaching available through instructional television that will act as magnets for faculty and their administrations.

> Time Compression:
> With intelligent planning and careful selection of visuals and visual metaphors, it is not unusual to get a time-compression of 7:1 with video as compared to "teacher talk".

Time Displacement:

> One great advantage of videotape in ability to record events and view them according to a personal schedule and pace. These benefits can not be underestimated with busy professionals working in business and industry . . . . From the faculty perspective, the benefits are equally important. The ability to record a class in advance of traveling is just one of the many examples.

Distance Learning:

> (T)he word tele-vision means the ability to see from a distance, to a distance, at a distance. The productivity gains and avoidance of travel expenses for business and industry (as well as for faculty) are usually enough to warrant wide-scale adoption . . . .

Simulation:

> Many technical classes lack realism in teaching due by substituting crude representations for the real thing. Small, compact, and portable video equipment is a natural for recording a variety of real examples and bringing them to the classroom.

Whole-Brained Approach:

> With the surge in video and computer displays, educators are once again interested in right-brained or intuitive approaches to technical subjects. By granting to the learner the ability to browse in a visual data-base . . . the student can grasp relationships that are frequently lost in a sea of text.

Improvements of Teaching:

> In teacher development,videotape provides to the instructor a non-judgemental record in order that analysis and improvement can take place.

Whereas Jones references those examples in which ITV can impact upon teaching, of greater import to this study are those areas in which ITV has actually been applied in support of engineering education. Minimally, these may include support for: on-campus instruction, lecture review, summer session classes, classroom demonstrations, and self-paced instruction. (110)

Prior to comparing the performance of off-campus study through videotape to on-campus activities, a brief reference to on-campus mediated engineering instruction is indicated. The following will offer a sense of the field's development. In the instances noted, student performance either did not suffer or showed various degrees of improvement, learning flexibility increased, or faculty found that they were able to transmit more information in a shorter period of time. All minimally supported Taveggia and Hedley who, in 1972, concluded that "televised instruction is as good as face-to-face instruction in conveying subject matter content to college students. . . . (T)he results of our analysis clearly suggest that math and science courses are equally well taught face-to-face or by television." (111)

Baldwin and Down (112) noted early efforts at Pennsylvania State University where, in 1958, Professor C. R. Carpenter recorded an entire chemical engineering course.

Survey results allowed Carpenter to note no significant differences in learning as compared to students enrolled in traditional lectures. However, he noted that students gained a great deal as a result of the flexibility offered through the media.

Thorn and Bundy reported on an early ITV experiment conducted at the University of New Mexico. (113) In a second semester sophomore course in electrical engineering, classes were prerecorded in 30-minute segments and were scheduled twice-weekly. Students were also required to attend a 50-minute recitation-quiz section. Faculty found that not only were they able to "cover" 50 minutes of normal lecture in the 30-minute periods, but that "it was clear quite early that most of the students were learning at least as well as, and probably better than, students taught by conventional methods in previous semesters." The authors followed their analysis with important observations: (114)

> Although teaching by television seems impersonal, the close view of the teacher provides more personal contact with the student than in possible with a large class.
>
> The limitation of student inability to ask questions is also not as critical as might be supposed. The instructor must deal with predictable questions which he knows from experience will arise. Undesireable questions are eliminated.

> A principal advantage of the telecourse method is that it centers the attention of the student where the instructor wants it and when he wants it.

At M.I.T., videotapes of a first-year physics course, supported by tutors, were offered to a sample of minority freshmen. This course was developed to both measure the effectiveness of the tutored videotape concept and also to serve as a secondary pedagogical aid. None of the students who participated in the mediated lectures failed the course. Fully one quarter of those who enrolled in the live lectures failed. These experiences lead M.I.T.'s professor Wesley Harris to comment:

> The concept of the instruction of students in the presence of a tutor from videotapes of formal lectures is revolutionary at the very least. From the observation of students immersed in this form of instruction, I feel that this format has great potential. <u>It may actually prove more effective than the traditional lecture/recitation if given the proper opportunity.</u> From the comments I have heard the students make, the ability to stop a lecture when there is a question in one's mind is far superior to the formal lecture. (115)

Positive reports were also recorded at Rochester Institute of Technology where, in 1971, a sophomore engineering statics course was prepared for delivery via the college's ITV network. Supplemented with specially developed texts, the course was broadcast to the campus' library and throughout the system of residence halls. In addition to viewing taped lectures, students meet twice-weekly with the course's faculty in recitation sessions.

Not only did a review of student records indicate equivalent performance, but R.I.T.'s Dean of Engineering was lead to comment that "the two faculty members were freed from lecturing (and) were able to teach more students and answer questions on a more individualized basis, then had been the case in the traditional program. . . . Nevertheless, the course reverted to the traditional classroom format in 1976 because many sophomore objected to the use of ITV. More than half did not attend the lectures during the last year of the program; they relied on printed materials and the recitation periods." (116)

Problems in student acceptance were also noted at Colorado State University, long the locus of experimentation in mediated engineering instruction. Its experiences offer further support for the assertion that "the attitudes of undergraduates towards ITV lectures is frequently unenthusiastic despite the fact that learning is not impaired (and) in some cases is enhanced." (117) To support freshman engineering education, CSU offered taped lectures from engineering courses and broadcast them throughout residence halls. At the same time, the university installed a tutorial program in dormitories for students who wanted individualized instruction. Although the taped material was available to all, CSU administrators were disappointed that only 25% of potential users took advantage of the opportunity. (118) On the other hand CSU faculty also noted that students were very satisfied with the use of mediated instruction when they were able to elect the course rather than being forced into it. In 1975, Professor Sanford Thayer, long regarded a pioneer in the use of video to support engineering education, developed a series of modules to compliment his course in engineering economy. Students were free to enroll in the traditional course or the one supported by ITV. Eighteen student enrolled in the latter and following a consistent pattern, "learned nearly as much as the regular class and also were able to work on it at their convenience. Considering these tradeoffs, the videopublished version compares quite favorably with the regular class." (119) Parenthetically, Gibbons recorded a greater acceptance of ITV on-campus among "high ability" students. (120)

While issues of student choice may impact on acceptance of mediated instruction, at many institutions, choice itself may soon become a moot question. In a number of instances, students now have no choice as to whether or not they enroll in courses fully or partially supported by instructional television. For instance, at the University of Massachusetts, the vast majority of summer session engineering courses are taped versions of courses offered previously. Further, given that large numbers of courses in that institution's departments of Electrical and Computer Engineering and Industrial Engineering/Operations Research are recorded for off-campus students participating in its Videotape Instructional Program student selection options among non-mediaided courses is very narrow. In both instances, on-campus students recognize that they have little choice. If they wish to enroll in the particular course, they are usually required to enroll in the mediated version as it is the only on offered. Few complaints have ever been raised.

In the report titled, "The Goals of Engineering Education," (121) Professor Joseph Pettit, now President of Georgia Institute of Technology, argued for the extension of high quality of engineering education beyond the classroom and into the workplace. The arguments in this report have provided the impetus for the development and expansion of

ITV in support of engineering continuing education. While many institutions of engineering higher education rose to the challenge, the effectiveness of "candid classroom" was basically assumed. Evaluations were rarely subjected to rigorous analysis. Yet, early work by Stutzman and Grigsby (122) and Kriegel (123) both noted off campus students performed with little difference when compared to their on-campus colleagues at Virginia Technological Institute, Iowa State University and Colorado State University. However, it was not until Gibbons, Kincheloe, and Down completed their evaluation of the Stanford Tutored Video Instruction Program (124) that widely read data became available.

With results comparable to studies performed on the on-campus use of instructional television, Gibbons data indicate that "as a group, the TVI students out-performed their on-campus counterparts; that is the average GPA of the TVI students . . . is higher than that of the on-campus students, even though the average of the admission qualifications for the TVI students is substantially lower than that of the on-campus students." (125)

Gibbon's second point is particularly important for it implies that the use of instructional television in its tutored mode might yield better performance from students with poorer credentials than would more traditional means.

Gibbons divided his sample into two groups, TVI participants who on the basis of their undergraduate records would have normally been granted admission to the traditional Stanford undergraduate program and those, who for inferior credentials, would have been excluded. Gibbons noted that students in the first category performed exceptionally with grades seemingly independent of admissions qualifications. Students in the second group did, as Gibbon's remarked, acceptably well, earning grades of "B" or better, even though they would not have been admitted to the Stanford "day" program. In fact, on the basis of their performance, students in the second category were admitted into the Stanford graduate program and earned the Master's degree with "creditable performance". Gibbon's summarized his initial data by declaring that the "sample of TVI students achieved an astonishing 3.57 GPA, exceeding not only those students using live television but almost 5% above the on-campus students! This result is made more remarkable by the fact that several of the TVI students had marginal academic qualifications that would have made their admission to the Stanford graduate program questionable or subject to probation." (126)

Gibbons' results are indicated below. (127) The data should be taken with a caveat due to a relatively small sample size. The grades of 302 on campus graduate students were compared to fifty-five students in the Stanford ITFS systems (real-time/interactive), six students in non-tutored videobased instruction, and twenty-seven student viewing videotapes supported by tutors.

TABLE #4

COMPARISON OF PERFORMANCE BETWEEN ON-CAMPUS STANFORD GRADUATE STUDENTS, ITFS STUDENTS, ITV STUDENTS WITH TUTOR AND ITV STUDENTS WITH NO TUTOR

Course Grade	Campus N=302	ITFS N=55	No Tutor N=6	With Tutor N=27
3.60				00 (3.57)
3.55				00
3.50				00
3.45				00
3.40	00 (3.38)			00
3.35	00			00
3.30	00			00
3.25	00			00
3.20	00	00 (3.19)		00
3.15	00	00		00
3.10	00	00	00 (3.1)	00
3.05	00	00	00	00
3.00	00	00	00	00

Follow-up evaluations were made after three years of program operation. The records of 82 TVI students participating in 1,803 quarter units (600 courses) were reviewed. Overall, their mean GPA was 3.37. When TVI students were again divided into two groups, the average for those whose record would have gained them admission into the traditional program was 3.59. This compared to an on-campus performance of 3.43. Students in the second TVI group still did "acceptably well".

Anticipating those who would argue the applicability of this study due to the differing experiential characteristics of the TVI students when measured against their on-campus counterparts, the authors offered that this could not be the case as "TVI students are drawn from the same population as students studying by ITFS whom they outperformed, so industrial experience or motivation cannot account for these results. Furthermore, other experiments show that on-campus TVI students also out-perform on-campus students who attended the regular lecture." (128)

Gibbons' analysis, that TVI students performed as well or better than on-campus students was offered taking the following guidelines into consideration:

> The attitude, personality, and instructional style of the tutor are very important. The tutor should be interested in helping the students in his group. He should attend all or nearly all of the videotape lectures. His competence is important but it is important that he is not so overqualified that he becomes bored

or impatient with a lack of understanding in the students.

Group size is also very important. If there are fewer than three students, opportunity for effective interaction is lacking and the method tends to be expensive. Group size greater than 8 to 10 tends to inhibit discussion and the frequency with which the tape is stopped. A group size of 3 to 8 seems optimum, although this can vary with personalities and acquaintance with each other.

Depending on the maturity of the student, commitment to a degree program or similar educational objective seems to be important for sustaining interest and motivation. Certainly, for most students, completion of graded projects and examinations results in a more productive educational experience.

Active classroom participation in the live class is desirable. For the subjects and audiences served to date, unrehearsed, unedited videotapes of classroom lectures may be used and, in fact, may have more "presense" and be more interesting to watch than tightly scripted, professional produced lectures.

It is important that the instructor be well organized knowledgeable in his subject, and free of annoying mannerisms. The charisma of a good instructor is emphasized on videotape.

For students employed in industry, attitudes of management play a very important role in the success of a continuing program. Job pressures that create long hours and interfere with family life markedly increase the difficulty of pursuing an educational program. (129)

Though they have become commonly accepted, some questions have emerged with Gibbons' assertions. For instance, he indicated that TVI students outperformed both their on-campus and ITFS colleagues. The argument seems less than convincing as in making the statement, he compared TVI student characteristics against ITFS participants who were also part-time students working in industry.

In 1984, Dr. Judith Lemon, Assistant Director of Stanford's TVI Program, reevaluated off-campus TVI and ITFS performance against that of the on-campus student population. In her unpublished internal audit, she compared the grades of 16,652 Stanford "day" FTE's against 1,771 ITFS students and 308 participants in the TVI program. She noted no <u>significant</u> differences among the three groups. The mean on-campus GPA was 3.40 versus 3.39 for the ITFS students and 3.47 for TVI enrollments.

Lemon concluded that while the TVI and ITFS students performed as well as full-time Stanford graduate students, their performance was not "significantly better than the . . . full-time students. Most likely the earlier results suggesting TVI students outperformed on-campus students were due to the extra attention accorded a new program, ie. the Hawthorne effect. (130)

Summary

Conclusions drawn from the research review support contentions of ITV efficacy as a tool for educational delivery. It has been proven effective delivering technical content in areas such as engineering and medicine. (131) ITV has also delivered positive effects through its simple use. Television in support of the academic process can be kept simple, but must be kept to the point. While faculty and student ambivalence continue, ITV's spread throughout higher education and other academic arenas continues. While it is not and should not be considered a total panacea, and can at best serve to supplement live instruction, it has continually be shown effective in the delivery of continuing professional engineering education. In so doing, it has demonstrated its ability to deliver highly technical instruction and support learning with a level of quality at least comparable to that available through traditional instruction.

As such, instructional television is one method that will offer some relief to the high technology manpower problem currently besetting the nation and the contributing dilemma involving insufficient engineering faculty. For the latter, it is truly a productivity enhancing device. This is not to say that faculty can augment their teaching loads through the use of instructional television without feeling additional strain and effort. Rather, the extra effort required is far less than that experienced were the faculty asked to travel to multiple off-campus instructional locations. Further, for the University, it becomes a cost-effective mechanism when one considers that high-level graduate courses often are taught to relatively small classes. Through ITV, the same faculty teaching before ten to fifteen on-campus students would be able to double that number from off-campus enrollments without a doubling of effort.

From the industrial perspective, ITV solves the problem of accessing continuing professional education for their employees without the inherent problems of traveling to academic sites at inconvenient times. With the efficiencies allowed either through the use of videotape or satellite delivered courseware, participants and their employers are able to take advantage of a panoply of instructional materials that has heretofore been unavailable. In fact, industry's problem has swung to the other pole. Where previously industry was dismayed with the paucity of available educational opportunities, it is now faced with the alternate but equally important problem of selecting appropriate materials from the broad panorama of instructional materials. In this regard, they must still follow the long-stated guidelines of knowing their personnel, gauging their needs, and effectively matching these to training opportunities.

The literature's review continues to support the contention that a tutor or local assistant is required to insure ITV's effectiveness in delivering education. Indeed, Gibbons noted (above) that the TVI students studying without support from tutors performed the poorest from among all of his sample groups. However, with trends indicating that tutorial assistance will become increasing less prevalent as technology supports the broader and deeper distribution the need for further clarification of the capacities in untutored videotaped engineering education becomes of paramount interest. The question to be addressed in the balance of this research is whether or not untutored videotaped instruction can deliver instruction that results in performance equal to that received by the on-campus student. It will further seek to determine whether or not there are distinguishing differences between the on and off-campus populations and identify those indicators which might portend performance for industrially-based employee/ students.

CHAPTER 3

Introduction

The purpose of this investigation has been to (1) determine the effectiveness of unassisted off-campus video-based instruction to students studying individually or in small groups in relation to conventional classroom instruction and (2) to identify within or between-group differences that would influence graduate performance.

Earlier research both in graduate and undergraduate engineering as well as in other disciplines has demonstrated the effectiveness of mediated instruction to groups of at least eight to ten students supported by tutors. Similarly, there is extensive literature that identifies student characteristics held to be influential predictors of academic performance. This undertaking purports to advance the understanding of off-campus video-based graduate engineering instruction by students studying alone or in small groups with no local support. Further, the research offers a comparative study of quantifiable characteristics effecting the graduate quality point average of on and off-campus students.

Context of the Study

The research has been conducted using data for on-campus resident graduate students in the Departments of Electrical and Computer Engineering and Industrial Engineering/Operations Research of the University of Massachusetts' College of Engineering. Off-campus students were individuals enrolled in degree (Electrical and Computer Engineering and Engineering Management concentration of Industrial Engineering/Operations Research) and non-degree programs offered through the College's Videotape Instructional Program, a component of its Office of Extended Engineering Education.

While particular to the University of Massachusetts, video-based graduate programming available through the Videotape Instructional Program is similar to that offered by a number of institutions throughout the country. Classes are taped in the "candid classroom" mode and off-campus enrollment per section is usually low.

In the "candid-classroom" mode, faculty teach before their on-campus students and the traditional lectures are taped. Following duplication, tapes are forwarded, accompanied by all notes and in-class handouts, to part-time registrants in industry. Tapes are unedited and on-campus questions and answers are recorded for the benefit of off-campus students. Faculty maintain telephone office-hours during which off-campus students may call in particular questions and seek additional clarification.

Unlike students in the Stanford Instructional Television Program, off-campus degree and non-degree graduate students enrolled through the Videotape Instructional Program are not supported by local tutors. Students are individually responsible for their conduct in particular courses but have the option of joining together with fellow employees at the same facility registered for the same course.

As on and off-campus student samples generally reflect those enrollment characteristics prevalent throughout the country, and since the Videotape Instructional Program parallels similar programs available nation-wide, results are generalizable throughout graduate engineering education.

Design of the Study

The Sample

This undertaking had the support of the University of Massachusetts' Vice Chancellor for Graduate Affairs and Dean of the College of Engineering. As such, the author was provided access to complete and accurate yet sanitized (student names were removed) graduate students records through the University of Massachusetts' Graduate Registrar.

Data on nearly 1,600 engineering graduate students enrolled through programs offered by the University of Massachusetts' College of Engineering were sampled. Each was enrolled during the period from Fall 1980 through the Spring 1985 academic semesters. Students participated in on and off-campus engineering curricula in the departments of

Electrical and Computer Engineering and Industrial Engineering/Operations Research. Off-campus graduate students were enrolled through the College of Engineering's Videotape Instructional Program (VIP), a component of its Office of Extended Engineering Education.

The on-campus student sample was limited to individuals graduated from American undergraduate institutions. This removed a large number of on-campus graduate students who were not native-born. Gibbons implemented a similar restriction on his selection process. Its effect is to equate on-campus students to their peers in industry and to remove a source of extraneous variability.

In addition to on and off-campus degree-seeking students, data, transcripts and application records for non-degree students enrolled in the VIP were recorded in the data base. Complete transcripts were available for these individuals. However, application records were minimal. The only available quantitative data were their dates of birth. These were matched to transcripts.

Student admissions records and associated transcripts were then divided into six program categories:

TABLE #5
DIVISION OF SAMPLE BY STUDENT CATEGORY

Category 1	On-Campus (Degree) Graduate Students Electrical and Computer Engineering
Category 2	Off-Campus Videobased (Degree) Graduate Students Electrical and Computer Engineering
Category 3	Off-Campus Videobased (Non-Degree) Graduate Students Electrical and Computer Engineering
Category 4	On-Campus (Degree) Graduate Students Industrial Engineering/Operations Research
Category 5	Off-Campus Videobased (Degree) Graduate Students Industrial Engineering/Operations Research (Engineering Management Concentration)
Category 6	Off-Campus Videobased (Non-Degree) Graduate Students Industrial Engineering/Operations Research (Engineering Management Concentration

Total sample size was 1,535 students, with the following breakdown by category:

TABLE #6
SAMPLE SIZE BY STUDENT CATEGORY

Category 1	n=228
Category 2	n= 87
Category 3	n=852
Category 4	n= 85
Category 5	n= 67
Category 6	n=216

At this point, a second group of students was removed from the study. Included were individuals who had registered for programs or individual courses and for a number of factors, withdrew. These transcripts showed records containing only grades of "W" (withdrawn/passing), "DR" (dropped), or "INC" (incomplete). With no letter grades, there was no quality point average. This mandated their removal from the study. This deselection process resulted in a new sample size of 1,028. Note the following:

TABLE #7
SAMPLE SIZE BY STUDENT CATEGORY
STUDENTS WITH QPA VERSUS STUDENTS WITH NO QPA

	Total N	Students With GPA	Students With No GPA
Category #1	228	219	9
Category #2	87	84	3
Category #3	852	424	428
Category #4	85	83	2
Category #5	67	66	1
Category #6	216	152	64
Total	1,535	1,028	507

Variables

Data extracted from student records included: date of birth, date of award of baccalaureate degree, scores on the Graduate Record Examination's Verbal, Quantitative, and Analytic tests, and undergraduate quality point average. Dates of birth and award of undergraduate degree were converted to reflect the students chronological age and the age of the bachelor's degree at the point of initial enrollment. All were viewed as independent variables against which graduate performance would be analysed. They were selected as each is considered in the admissions process for both on and off-campus degree students and are widely accepted and used throughout higher education. Use of these quantifiable independent variables adds to the generalizability of this study.

Academic grades were also extracted from individual records and considered measurements of performance. Though some question whether grades accurately reflect learning, University policies requiring off-campus video graduate students to be graded no differently from students on-campus provide a base for comparative analysis.

Individuals' academic course records and graduate quality point average were matched to personal information. To insure that student records reflected specific courses, each course section was assigned an individual code reflecting the offering department, course number, semester, and year. This distinguished between enrollment in courses having the same name yet offered by differing academic departments as well as different sections of the same course. For instance, courses titled "Software Engineering" were offered by both the Departments of Mechanical Engineering and Computer and Information Science. Identifiers were assigned to each course indicating the offering department and semester offered. The following illustrates the coding of courses. Electrical and Computer

Engineering course #566, offered in the Fall 1984 semester was coded 841 (1984, Fall) 1 (ECE) 566 (course #). The code 832 2 520 reflected Industrial Engineering #520 offered during the Spring 1983 academic semester.

The following scale was used to translate letter grades into numerical scores: A=4.0; AB=3.5; B=3.0; BC=2.5, C=2.0; CD=1.5; D=1.0; F=0.

Courses with grades of Pass, Withdraw/Passing, Dropped, or Incomplete were excluded from individual's records as no quality point average could be assigned. Following the University policies, courses recorded as having grades of Withdraw/Failing or Incomplete/F were translated to "F" and incorporated into the data base.

Hypotheses and Treatment of Data

Though the majority of this analysis ignored those without grades, note was taken of the large number of non-degree video-based students who did not complete courses. In Electrical and Computer Engineering, the attrition rate among non-degree VIP enrollees slightly exceeded 50% (428 out of 852). A 30% drop-out rate (64 out of 216) was registered for those enrolled as non-degree students in Industrial Engineering/Operations Research courses. While both represent disturbingly high percentages, and raise important questions, insufficient data was available to allow for substantial analysis. Recall that date of birth was the only quantifiable data available. As a result, this important question remains a concern for future research.

The analyses are divided into three sections: (1) a detailed investigation of the interplay among and between the independent variables upon group performance; (2) a comparison of actual off-campus degree student grade point average to predicted performance levels established by on-campus degree students; and (3) a course-by-course analysis to determine the existence of significant performance differences between on and off-campus degree students.

The initial question concerned the relationship to grades of the quantifiable variables available for each student. The variables included: chronological and degree ages at the point of enrollment, GRE verbal, quantitative, and analytic test scores, and undergraduate grade point averages. These were correlated to the performance of all students in the sample. This was done to assess the existence of significant correlations among the testable criteria. Variables were also subjected to regression analysis to asses their predictive relationship to performance. Stepwise regressions were performed to determine that combination of variables offering the greatest predictive value for the entire sample.

Following this gross variable analysis, students were divided into subgroups to determine, through one-way analyses of variance supported by post-hoc examination whether within group variation resulted in significant differences in graduate performance.

Again, these procedures were conducted on a sample that was undifferentiated for on or off-campus participation or engineering discipline. This segment of the analysis also amalgamated all courses offered in the study period. No effort was made to distinguish between courses or whether or not off-campus students enrolled in a particular course taken by on-campus participants. This section's sole purpose was determine whether and to what extent, the variables exercised general effects.

While offering general sample characteristics, this aspect of the analysis concerned itself with the null-hypothesis claiming that within-group differences among the independent variables offered no statistically significant relationship to variation in the sample's graduate performance.

To further develop differences, the sample was divided between two engineering disciplines, electrical and computer engineering and industrial engineering/operations research. Each was then subdivided into groups of on and off-campus degree students within each discipline. One-way analyses of variance, supported by post-hoc Scheffe analyses where appropriate, were conducted to ascertain differences between on and off-campus groups for each of the independent variables plus graduate performance. Results respond to the null-hypotheses suggesting that no statistically significant differences exist between on and off-campus students (in either electrical and computer engineering or industrial engineering/operations research) when measured against graduate quality point average, age, degree age, GRE Verbal, Quantitative, and Analytic test scores, and undergraduate average.

In order to assess the validity of the null-hypothesis suggesting that no statistically significant variations in graduate performance would result from variations within and between the independent variables, the sample was divided into the six identifying categories. One-way analyses of variance (ANOVAs) were carried-out and where warranted, supported by post-hoc Scheffe tests for pair-wise comparisons.

One-way ANOVA's seeking significant differences in performance on account of student age were conducted for on and off-campus degree and non-degree students in both engineering disciplines (Categories #1-#6). Limitations in available data allowed similar tests for GRE Verbal, Quantitative, and Analytic scores as well as undergraduate quality point average for only on and off-campus degree students. Regression models were also established to ascertain a variable's predictive quality in determining grades for students in each grouping. Finally, stepwise regression analyses were conducted to determine the combination of variables within each student category that, acting in concert, provided the best predictive capability.

The intent of this exercise was to determine, as finely as possible, those active and significant relationships at work within each of the six categories. Results offered offered predictive tools relating to student performance and provided comparative data on student characteristics.

Throughout the following chapter, the reader will no doubt take note that correlations and predictive values of the selected variables, acting both singularly and in concert, are generally low. While low values generally reflect the existence of factors outside those subjected to measurement, the compression of passing graduate grades into upper levels ("A", "AB", and occasionally "C") reduces the variability within the dependent variable. With less grade variation, the correlations and regression analyses could be expected to fall to lower levels. While this does not refute the notion that outside factors are at work, it should be considered within the framework of the data presented.

To respond to the null-hypothesis that no statistically significant differences could be found between actual graduate performance of off-campus graduate students (in both disciplines) when compared to predicted performance levels established by on-campus students, formulae for predicted levels of performance were developed from stepwise regression analyses on the independent variables against performance for on-campus Electrical and Computer Engineering and Industrial Engineering/Operations Research students. Off-campus actual grades were correlated to on-campus predictors for both majors. Predicted performance levels were subjected to regression analysis against actual performance to establish the degree to which they might predict actual off-campus grades. Finally, actual performance by off-campus students and predicted levels of performance were subjected to one-way analyses of variance to establish whether one was significantly different from the other.

Results from these tests will indicate how closely on and off-campus degree students perform, when the independent variables are held constant and the major differentiating factor being the instructional modality. The data will then allow statements affirming or rejecting the contention that off-campus students with admissions records similar to those of their on-campus colleagues, will perform with no statistically significant variation in level.

To this point, no effort was made to assess student performance on a course-by-course basis. It now becomes incumbent to determine whether performance in an individual course is effected by a student's category. These final tests respond to the null-hypothesis that no statistically significant variations in grades will exist between on and off-campus students enrolled in the same course.

Towards this end, enrollment patterns were surveyed among all courses offered in the departments of Computer and Information Sciences, Electrical and Computer Engineering, Industrial Engineering/Operations Research, Mathematics, and Mechanical Engineering from the Fall 1980 through Spring 1985 academic semesters. From this roster, course sections were selected if their enrollment reflected at least two on and two off-campus (VIP) degree students. Sections were not included, regardless of existing large numbers of non-degree VIP students, unless they met this criteria.

Following these guidelines, 36 course sections were available for study in Electrical and Computer Engineering, 17 in Industrial Engineering/Operations Research, and one from the Department of Computer and Information Sciences. Analyses of variance were run on each to determine whether on-campus performance was significantly different from that exhibited by off-campus participants.

Results of these efforts offer data detailing the characteristics and interplay of a number of quantifiable variables upon students' graduate performance. Further, it evidences the viability of non-tutored video-based instruction to small pockets of off-campus engineers as a valued educational delivery tool. In so doing, it does not argue the point that tutor-supported off-campus instruction is not the desirable of the two options. Rather, the research only rejects the hypothesis that off-campus students, enrolled in non-tutored video-based engineering instruction, suffer from the instructional delivery system. In so doing, one might well affirm the contention that non-tutored mediated instruction in graduate engineering is an appropriate instructional tool allowing course distribution to small pockets of students whose class size does not efficiently allow for formal tutorial support. The research offers that quality learning can occur by students studying on their own or in small unassisted groups.

CHAPTER 4

THE DATA

RELATIONSHIP OF THE VARIABLES TO THE TOTAL STUDENT SAMPLE

> No statistically significant differences will occur in graduate grade point average among engineering students enrolled in on-campus and video-based off-campus engineering graduate program in Electrical and Computer Engineering and Industrial Engineering/Operations Research when measured against: chronological age at the point of initial matriculation; degree age at the point of initial matriculation; scores of the Graduate Record Examination's verbal, quantitative, and analytic tests; and undergraduate quality point average.

The first issue concerns the impact of variables upon graduate performance. The student sample consists of an amalgamation of all on and off-campus degree and non-degree enrollees in the data base. It combines students primarily participating in the department of Electrical and Computer Engineering and Industrial Engineering/Operations Research. As such, the analysis of relatively gross and seeks to determine only those general relationships evident between the variables and the total sample. The independent variables include: student age and degree age at the point of initial enrollment; scores on the GRE verbal, quantitative, and analytic tests; and undergraduate grade point average.

Initial review of the data suggests that none of the independent variables offers substantial impact upon performance. Note the following for descriptive and intercorrelative data:

TABLE #8

RELATIONSHIP OF VARIABLES TO TOTAL STUDENT SAMPLE

	AGE	DEGREE AGE	GRADUATE RECORD EXAM VERBAL	QUANT	ANAL	UGRAD QPA	GRAD QPA
N	1,012	450	405	405	368	405	1,025
NMISS	13	575	620	620	657	620	0
MEAN	28.70	3.66	510.2	665.1	527.0	3.11	3.25
MEDIAN	27.00	1.00	520.0	670.0	575.0	3.13	3.44
STDEV	6.44	5.24	123.0	78.1	114.5	0.43	0.67
MAX	63.00	33.00	800.0	800.0	800.0	4.00	4.00
MIN	18.00	0	200.0	270.0	240.0	1.92	1.00

TABLE #9

CORRELATIONS OF INDEPENDENT VARIABLES TO TOTAL SAMPLE

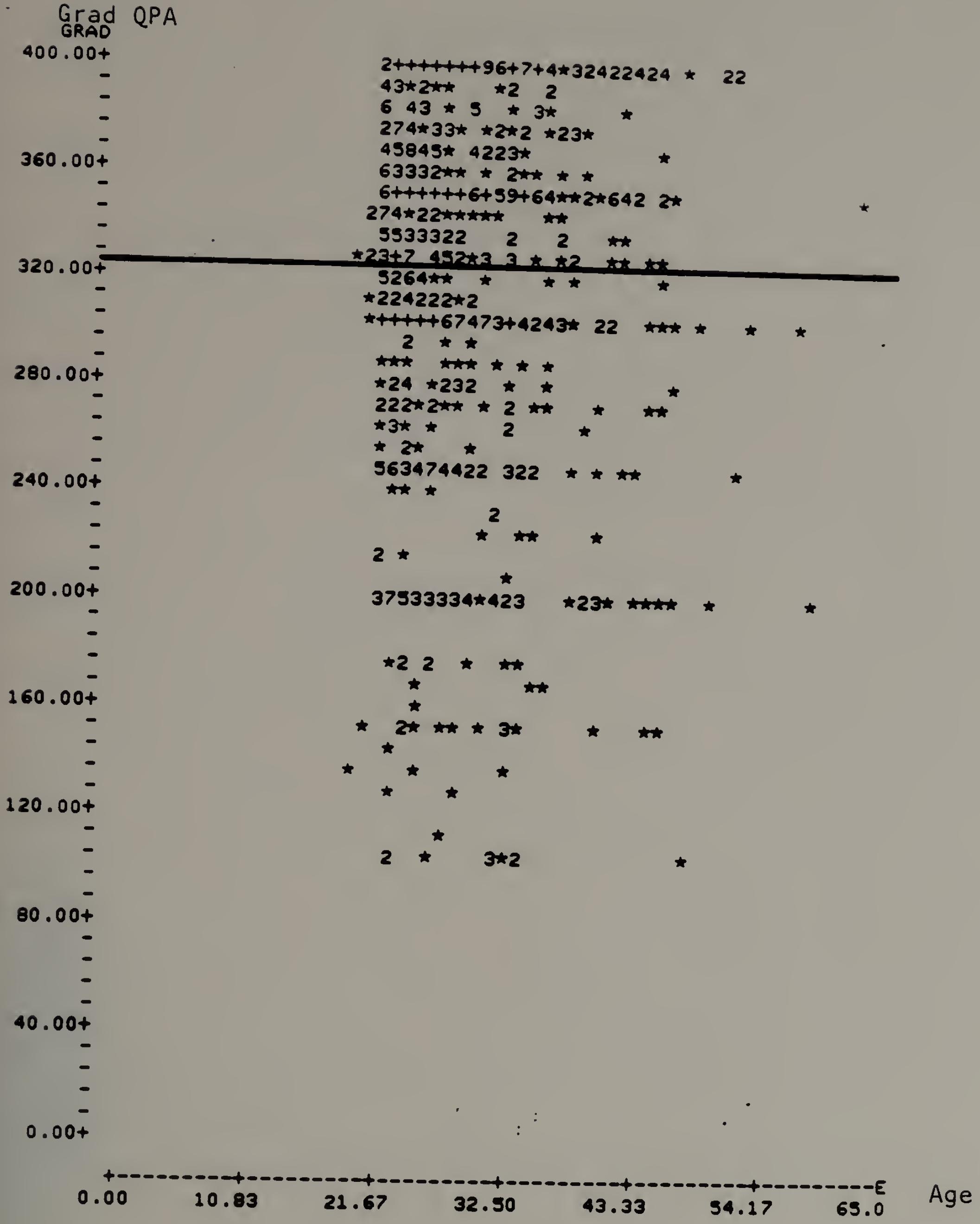
	AGE	DEGREE AGE	GRADUATE RECORD EXAM VERBAL	QUANT	ANAL	UGRAD QPA
DEGREE AGE	-.012					
GREV	.244	.041				
GREQ	-.093	-.027	.417			
GREA	-.086	-.051	.624	.587		
UGRAD QPA	-.262	.048	.032	.181	.127	
GRAD QPA	.007	-.056	.185	.240	.200	.160

With the exception of age and degree age, all of the relationships are significant to the .01 level when correlated to performance. Age is not a statistically significant correlate. Degree age is significant at the .05 level. While statistically significant to their respective levels, the correlations are relatively low. Acting individually, they clearly do not substantially reflect strong relationships on performance.

The looseness of the correlations are displayed in the following graphs describing the regression of each of the independent variables on graduate quality point average.

PLOT #1

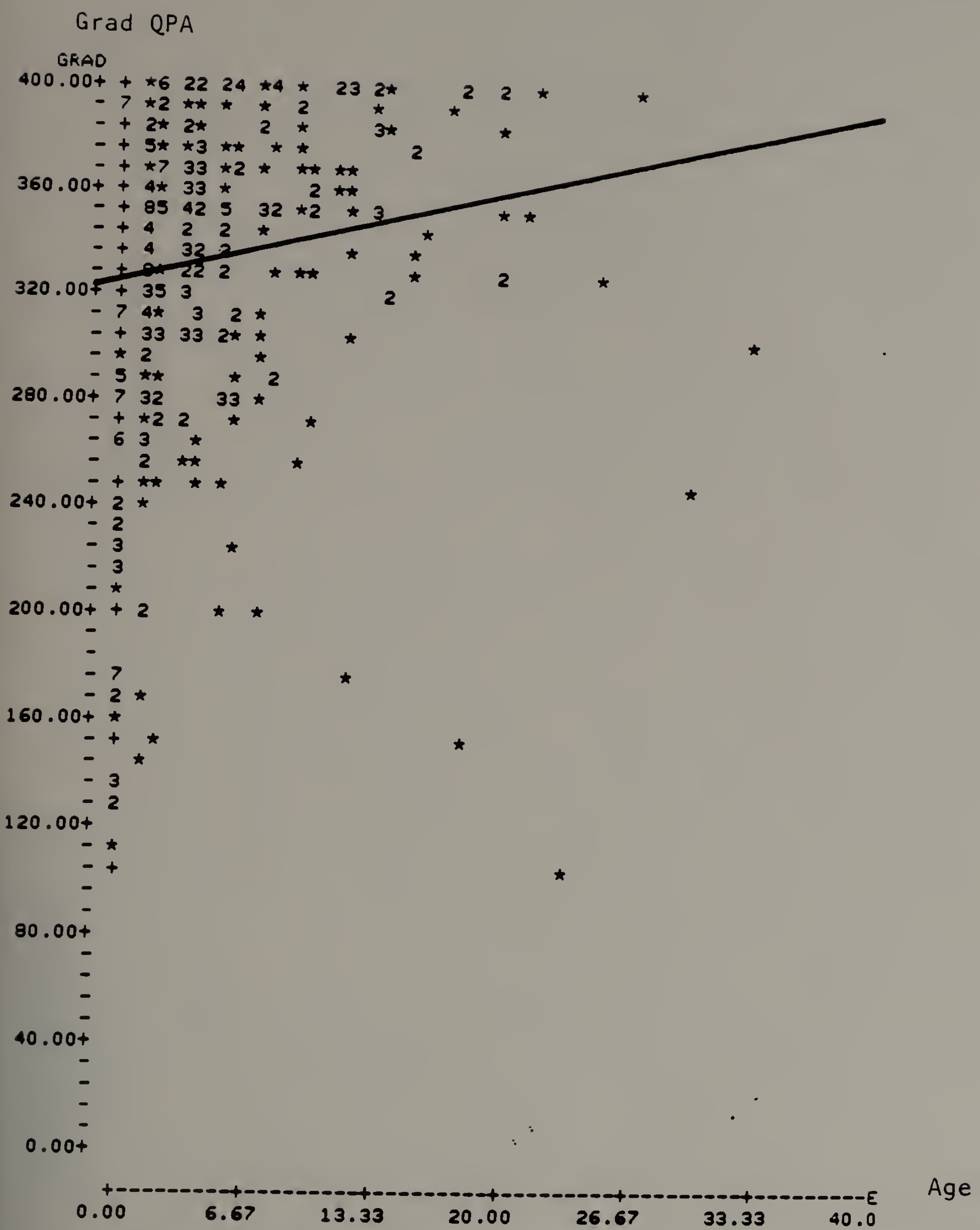
AGE VERSUS GRADUATE QPA FOR ALL STUDENTS



Graduate QPA = 323 + 0.064 Age
Correlation: .006
r squared: 0

PLOT #2

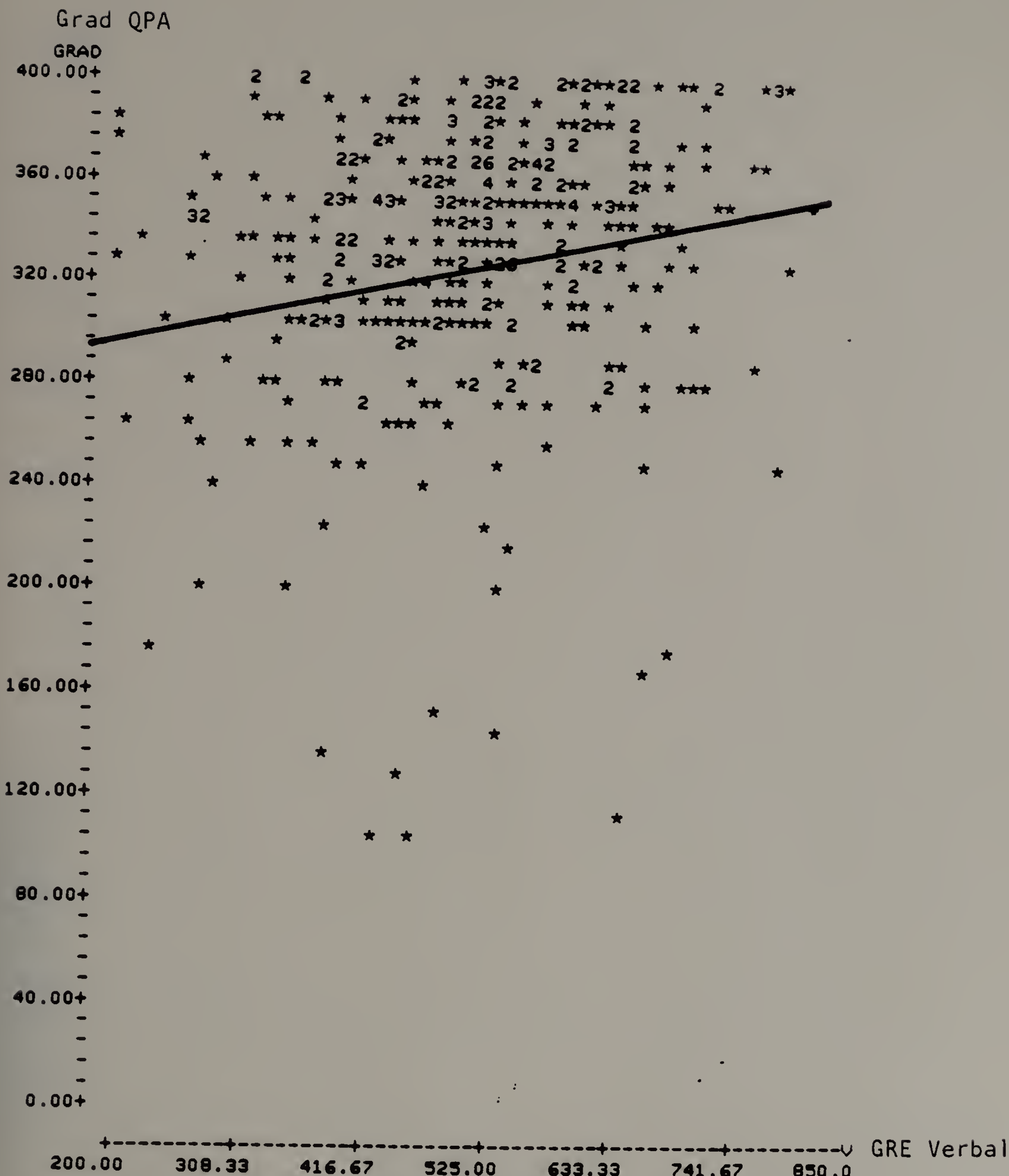
DEGREE AGE VERSUS GRADUATE QPA FOR ALL STUDENTS



Graduate QPA = 322 + 1.85 Degree Age
Correlation: .108
r squared: 1.2%

PLOT #3

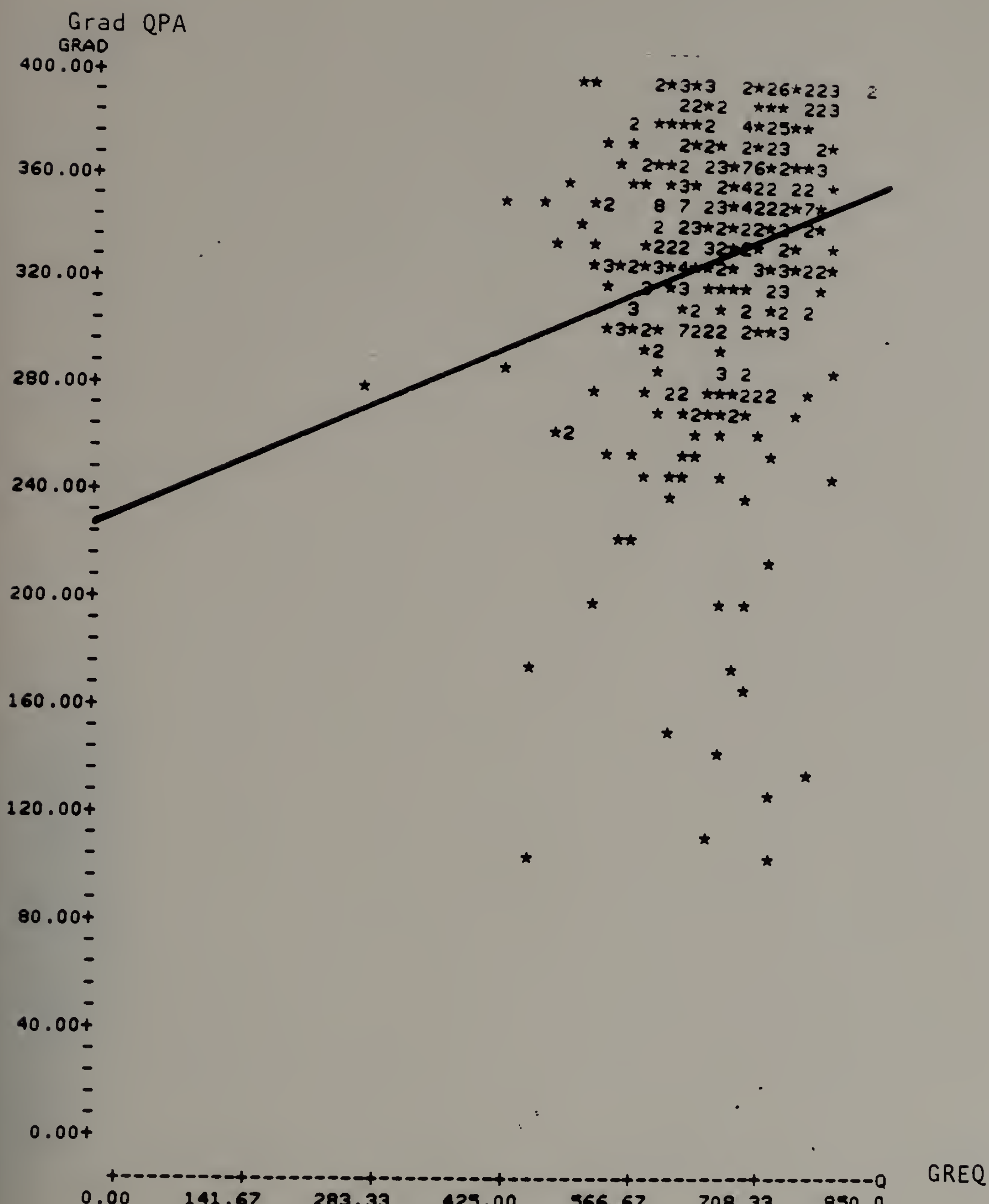
GRE VERBAL VERSUS GRADUATE QPA FOR ALL STUDENTS



Graduate QPA = 293 + 0.0786 GREV
Correlation: .185
r squared: 3.2%

PLOT #4

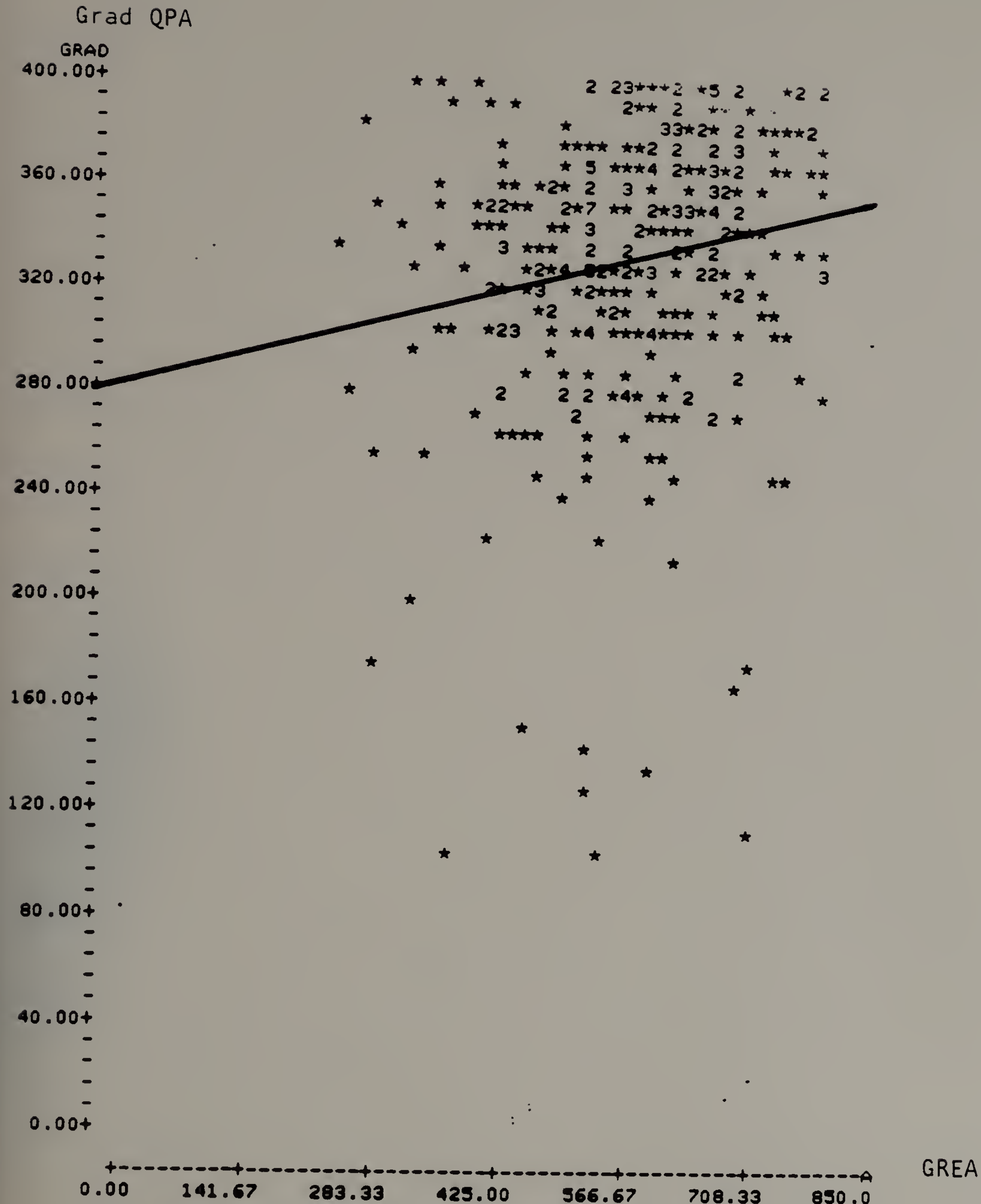
GRE QUANTITATIVE VERSUS GRADUATE QPA FOR ALL STUDENTS



Graduate QPA = 227 + .160 GREQ
Correlation: .240
r squared: 5.5%

PLOT #5

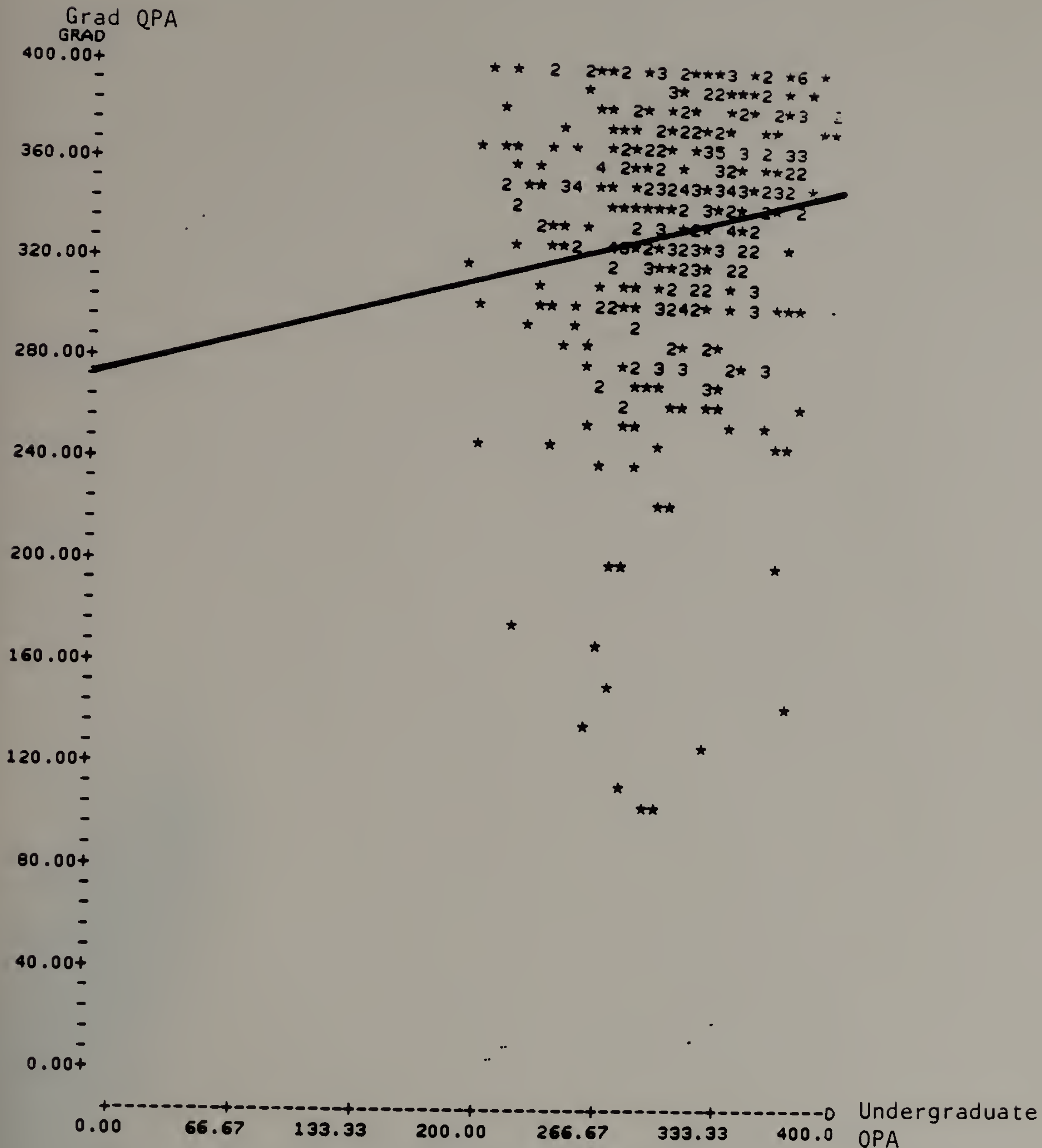
GRE ANALYTIC VERSUS GRADUATE QPA FOR ALL STUDENTS



Graduate QPA = 279 + 0.0914 GREA
Correlation: .200
r squared: 3.7%

PLOT #6

UNDERGRADUATE QPA VERSUS GRADUATE QPA FOR ALL STUDENTS



Graduate QPA = 275 + 0.189 Undergraduate QPA
Correlation: .160
r squared: 2.3%

To assess strengths as predictors, each of the variables was individually regressed against graduate performance for the total sample. The variables' regression analyses resulted in consistently low values for *r* squared and offer additional indication that other factors were at work in determining graduate quality point average.

TABLE #10

REGRESSION ANALYSES
INDEPENDENT VARIABLES AGAINST TOTAL STUDENT SAMPLE

Age Regressed against Graduate QPA

Formula:	Graduate QPA = 323 + (0.074) (Age)
N:	1,012
r squared:	0%
r squared Adjusted for Degrees of Freedom:	0%
(Not statistically significant: *F*=0.05)	

Degree Age Regressed against Graduate QPA

Formula:	Graduate QPA = 328 - (0.730) (Degree Age)
N:	450
r squared:	0.3%
r squared Adjusted for Degrees of Freedom:	0.1%0(Not statistically
significant: *F*=1.40)	

GRE Verbal Regressed against Graduate QPA

Formula:	Grad = 293 + (0.0786) (GREV)
N:	405
r squared:	3.4%

r squared Adjusted for
Degrees of Freedom: 3.2%
(Statistically significant at the .01 level: *F*=14.31)

GRE Quantitative Regressed against Graduate QPA

Formula:	Grad = 227 + (0.160) (GREQ)
N:	405
r squared:	5.7%
r squared Adjusted for Degrees of Freedom:	5.5%

(Statistically significant at the .01 level: *F*=24.55)

GRE Analytic Regressed against Graduate QPA

Formula:	Grad = 279 + (0.091) (GREA
N:	368
r squared:	4.0%
r squared Adjusted for Degrees of Freedom:	3.7%

(Statistically significant at the .01 level: *F*=15.22)

Undergraduate QPA Regressed against Graduate QPA

Formula:	Grad = 275 + (0.189) (UGRAD)
N:	405
r squared:	2.6%
r squared Adjusted for Degrees of Freedom:	2.3%

(Statistically significant at the .01 level: F=10.59)

Two follow-up analyses were conducted given that none of the variables acting independently offered strength in predicting graduate performance. First, a stepwise regression analysis was initiated to determine those variables acting in concert that offered the greatest power. Secondly, each of the variables was stratified in order to determine their relative strengths in predicting graduate grade point average.

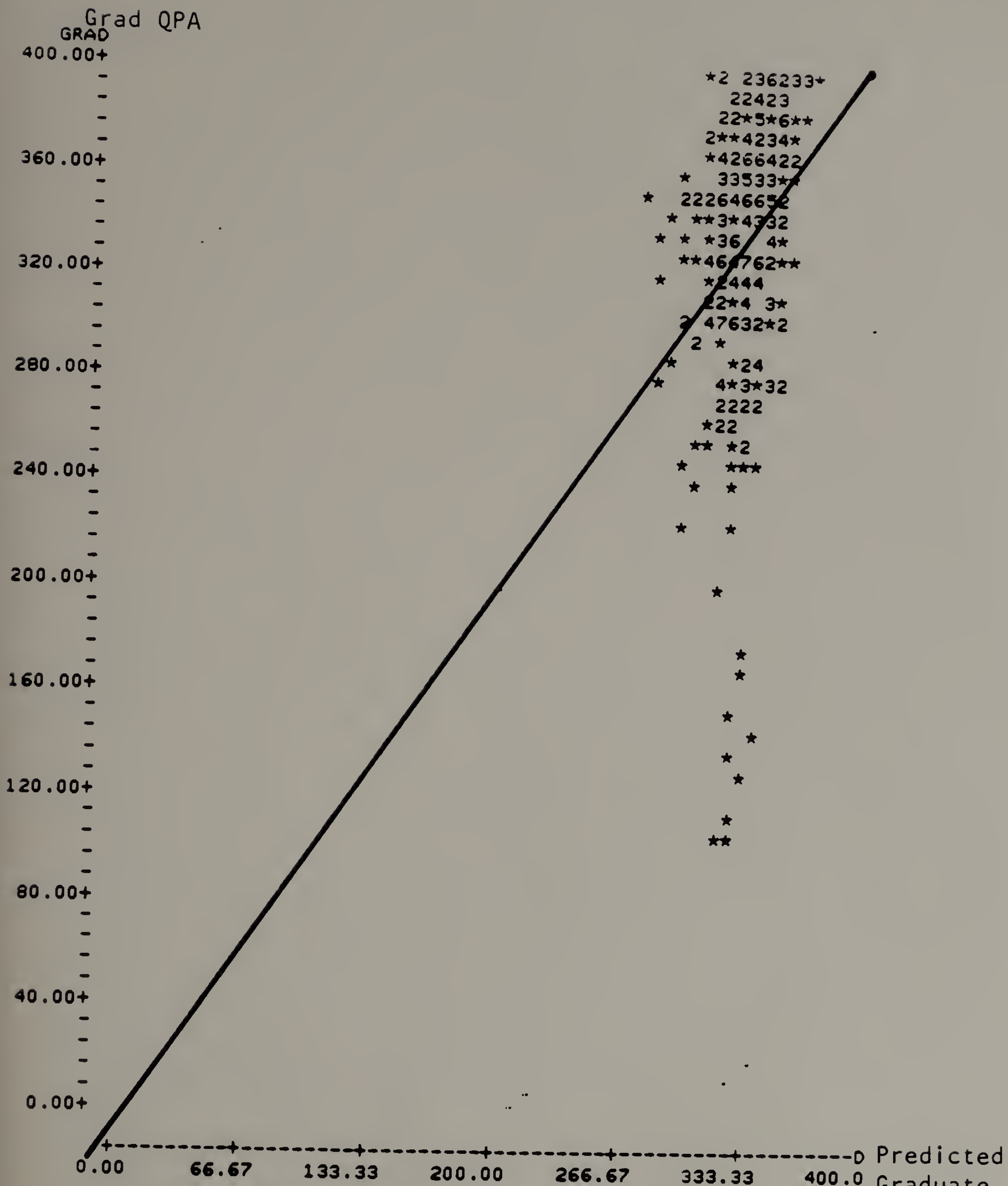
Results of the stepwise regression analyses indicate that the best predictive power comes from combining scores on the GRE verbal and quantitative tests. While the results are significant to the .01 level (F=14.25), the predictive value (r squared) of this best combination is only 7.47%. This continues to suggest the existence of other working factors beyond those of the identified variables.

Note the following plot illustrating the interaction of predicted versus actual graduate quality point average. It uses the formula, established by the stepwise regression analysis: Graduate Performance = 224 + (0.0438) (GREV) + (0.132) (GREQ). It is based on a sample size totaling 405 cases (each having all of the variables present). The correlation between actual and predicted performance is .257.

Though the results of these analyses are low, recall that this is the grossest of analyses and its purpose to solely to provide introductory information. The sample against which the variables were analyzed was heterogeneous, consisting of students enrolled both on and off-campus, in degree and non-degree programs, and in two very different disciplines. Further, the variables were not subdivided. Consequently, the minimal levels of correlation and powers of prediction should not be surprising.

PLOT #7

STEPWISE REGRESSION
ALL VARIABLES VERSUS GRADUATE QPA FOR ALL STUDENTS



Actual Grad QPA = 224 + 0.0438 GREV + 0.132 GREQ
Correlation: .257
r squared: 6.6%

RELATIONSHIP OF THE STRATIFIED VARIABLES TO THE TOTAL STUDENT SAMPLE

Acting both individually and in concert, the independent variables (age, degree age, GRE verbal, quantitative, and analytic test scores, and undergraduate quality point average) offer correlate and predictive measurements of minimal value. To ascertain whether subsets of the variables provided stronger tools, each wasstratified. One-way analyses of variance (ANOVA) were then conducted to determine whether statistically significant variations in performance could be realized from their interaction with the main variables' subgroups. In addition, regression analyses were carried-out to yield the predictive power of each subgroup upon graduate quality point average.

Note the following results.

TABLE #11

EFFECT OF AGE ON GRADUATE QUALITY POINT AVERAGE

Description

Age	All	20-25	26-30	31-35	36 +
N	1,025	414	288	171	138
Mean QPA	3.25	3.23	3.29	3.22	3.25
Median QPA	3.44	3.33	3.50	3.50	3.50
StDev	0.67	0.61	0.64	0.81	0.70

One Way Analysis of Variance

```
                              Individual 95% CI for Mean
 Age                          Based on Pooled StDev
Level  N  Mean   StDev   ----+---------+---------+---------+--
20-25 414 3.23   .612        (--------*--------)
26-30 288 3.29   .644               (----------*---------)
31-35 171 3.22   .815    (-------------*-----------)
36 +  138 3.25   .704      (--------------*--------------)
                         ----+---------+---------+---------+--
Performance (Grad QPA) 3.150     3.225     3.300     3.375
F=0.61:  Not statistically significant
```

Correlations and Regression Analysis

Age Level	Correlation to Performance	r Squared	r Squared Correc. for Deg of Freed,	Signfcnce
All	.007	0%	0%	No
20-25	.058	.3%	.1%	No
26-30	.064	.4%	.1%	No
31-35	.108	1.2%	.6%	No
36 +	-.110	1.2%	.5%	No

Summary: Age groupings do not provide statistical significance in accounting for variations in graduate performance. Age grouping provide little predictive power for performance. Correlation of the age subgroups to performance are low.

TABLE #12

EFFECT OF DEGREE AGE ON GRADUATE QUALITY POINT AVERAGE

Description

Degree Age	All	0-1	2-3	4-5	6-10	11 +
N	450	226	70	51	56	47
Mean QPA	3.34	3.25	3.42	3.35	3.43	3.52
Median QPA	3.44	3.33	3.50	3.45	3.50	3.71

StDev	0.53	0.54	0.40	0.45	0.50	0.66

One Way Analysis of Variance

```
                             Individual 95% CI for Mean
Degree                       Based on Pooled StDev
 Age    N  Mean  StDev   ---+---------+---------+---------+---
 0-1   226 3.25  .540    (----*----)
 2-3    70 3.42  .400              (--------*--------)
 4-5    51 3.35  .450       (----------*---------)
6-10    56 3.43  .501             (---------*---------)
11 +    47 3.52  .656                    (---------*----------)
                         ---+---------+---------+---------+---
Performance (Grad QPA) 3.22       3.36      3.50      3.64
F=3.95:  Significant to the .01 level
```

Correlations and Regression Analysis

Degree Age	Correlation to Performance	r Squared	r Squared Correc. for Deg of Freed,	Signfcnce .05 Level
All	.119	1.4%	1.2%	
0-1	-.066	.3%	.1%	No
2-3	-.002	.4%	.1%	No
4-5	-.109	1.2%	.6%	No
6-10	.180	3.3%	1.5%	No
11 +	-.276	7.6%	5.6%	No

Summary: In general, degree age is a statistically significant variable in accounting for differences in graduate performance, though the correlations and levels of predictors are low. No subgroup in the degree age variable is a statistically significant predictor of performance and the strongest correlation to performance exists in that group with a degree age older than eleven.

TABLE #13

EFFECT OF PERFORMANCE OF GRE VERBAL TEST ON GRADUATE QUALITY POINT AVERAGE

Description

GRE Verbal	All	200-400	401-500	501-600	601-700	701 +
N	1,025	81	110	126	65	23
Mean QPA	3.25	3.19	3.27	3.42	3.39	3.55
Median QPA	3.44	3.27	3.33	3.50	3.50	3.65
StDev	0.67	0.53	0.54	0.45	0.58	0.47

One Way Analysis of Variance

```
                                Individual 95% CI for Mean
 GRE                            Based on Pooled StDev
Verbal    N  Mean StDev  -------+---------+---------+---------
200/400  81  3.19 .526    (----*----)
401-500 110  3.27 .544        (----*----)
501-600 126  3.42 .446                 (---*----)
601-700  65  3.39 .580             (------*-----)
701 +    23  3.44 .47.5                (---------*---------)
                         -------+---------+---------+---------
Performance (Grad QPA)        3.20      3.40      3.60
```

F=3.47: Significant to the .01 level

Correlations and Regression Analysis

GRE Verb	Correlation to Performance	r Squared	r squared Correc. for Deg of Freed,	Signfcnce
All	.185	3.4%	3.2%	.01 Level
200-400	.034	.1%	0%	No
401-500	.054	.3%	0%	No
501-600	.016	0%	0%	No
601-700	-.133	1.8%	0.2%	No
701 +	.157	2.5%	0%	No

Summary: The effect of the GRE Verbal test is generally significant in accounting for variations in performance. Its correlations and predictive levels are low. Variations in performance within GRE Verbal subgroups are statistically significant in accounting for variation in graduate performance. No GRE Verbal subgroup offers a statistically significant predictor.

TABLE #14

EFFECT OF PERFORMANCE ON GRE QUANTITATIVE TEST ON GRADUATE QUALITY POINT AVERAGE

Description

GRE Quant	All	200-500	501-600	601-700	701 +
N	1,025	11	72	180	142
Mean QPA	3.25	2.76	3.27	3.29	3.47
Median QPA	3.44	2.83	3.27	3.39	3.55
StDev	0.67	0.80	0.42	0.52	0.50

One Way Analysis of Variance

```
                             Individual 95% CI for Mean
 GRE                         Based on Pooled StDev
Quant    N  Mean StDev --------+---------+---------+--------
200/500  11 2.76 .799  (---------*---------)
501-600  72 3.27 .417                        (---*---)
601-700 180 3.29 .524                           (--*-)
701 +   142 3.47 .502                                 (--*--)
                       --------+---------+---------+--------
Performance (Grad QPA)       2.70      3.00      3.30
```

$\underline{F}$=9.00: Significant to the .01 level

Correlations and Regression Analysis

GRE Quant	Correlation to Performance	$\underline{r}$ Squared	$\underline{r}$ squared Correc. for Deg of Freed,	Signfcnce
All	.240	5.7%	5.5%	.01 Level
200-500	.014	0%	0%	No
501-600	.073	.5%	0%	No
601-700	.025	.1%	0%	No
701 +	.180	3.3%	2.6%	.05 Level

Summary: The effect of the GRE quantitative test in generally significant in accounting for variations in performance. However, its predictive capabilities are low. Scores above 700 on the GREQ offer a significant but low performance predictor. The analysis of variance does significantly indicate that variations in performance will result from differences in scores received.

TABLE #15

EFFECT OF PERFORMANCE ON GRE ANALYTIC TEST ON GRADUATE QUALITY POINT AVERAGE

Description

GRE Analytic	All	200-500	501-600	601-700	701 +
N	1,025	96	122	109	41
Mean QPA	3.25	3.19	3.26	3.45	3.39
Median QPA	3.44	3.27	3.31	3.50	3.60
StDev	0.67	0.51	0.54	0.44	0.61

One Way Analysis of Variance

```
                              Individual 95% CI for Mean
 GRE                          Based on Pooled StDev
Analytic N   Mean StDev ----------+---------+---------+------
200-500   96 3.19 .512  (-------*------)
501-600  122 3.26 .543         (-----*------)
601-700  109 3.45 .438                     (------*------)
701 +     41 3.39 .615              (----------*-----------)
                        ----------+---------+---------+------
Performance (Grad QPA)          3.22      3.36      3.50
```

F=5.28: Significant to the .01 level

Note: significant differences exist to the .05 level between students scoring 501-600 on the analytic GRE from those scoring in the 601-700 range.

Correlations and Regression Analysis

GRE Verb	Correlation to Performance	r Squared	r squared Correc. for Deg of Freed,	Signfcnce
All	.200	4.0%	3.7%	.01 Level
200-500	.080	.6%	0%	No
501-600	.078	.6%	0%	No
601-700	.065	.4%	0%	No
701 +	.271	7.4%	5.0%	No

Summary: Variations in GREA test scores provide statistically significant factors that account for variation in graduate performance. Although the test scores offer significant predictive capability, they are low. Individual subgroups offer no statistically significant predictive power.

TABLE #16

EFFECT OF PERFORMANCE OF UNDERGRADUATE QUALITY POINT AVERAGE ON GRADUATE QUALITY POINT AVERAGE

Description

Ugrad QPA	ALL	0-2.50	2.51-3.00	3.01-3.50	3.51-4.00
N	1,025	39	111	177	78
Mean QPA	3.25	3.37	3.19	3.36	3.49
Median QPA	3.44	3.45	3.28	3.44	3.60
StDev	.67	.45	.60	.45	.49

One Way Analysis of Variance

```
                           Individual 95% CI for Mean
Ugrad                      Based on Pooled StDev
QPA          N Mean StDev---------+---------+---------+-------
0-2.50      39 3.37 .454      (-----------*----------)
2.51-3.00  111 3.19 .604(------*------)
3.01-3.50  177 3.36 .446            (----*-----)
3.51-4.00   78 3.49 .492                  (-------*-------
                      ---------+---------+---------+-------
Performance (Grad QPA)        3.22      3.36      3.50
```

$\underline{F}$=5.75: Significant to the .01 level

Note: Significant differences exist, to the .01 level, between those students who had undergraduate quality point averages between 2.51-300 and those whose undergraduate performance was in the 3.01-3.50 range. No statistically significant differences exist in performance among students having undergraduate averages of 3.01 to 3.50 versus those with higher undergraduate quality point averages.

Correlations and Regression Analysis

Ugrad QPA	Correlation to Performance	$\underline{r}$ squared	$\underline{r}$ squared Correc. for Deg of Freed,	Signfcnce
All	.160	2.6%	2.3%	.01 Level
0-2.50	.052	.3%	0%	No
2.51-3.00	-.004	0%	0%	No
3.01-3.50	.106	1.1%	.6%	No
3.51-4.00	.232	5.4%	4.1%	.05 Level

Summary: Variation in undergarduate QPA is a statistically significant factors in accounting for variation in graduate performance. The undergraduate QPA is generally a significant though weak predictor of performance as is its range of 3.51 to 4.00 on graduate quality point average.

No extraordinary relationships emerge from the analysis of stratified variables against graduate performance. This would partially result from the heterogeneous nature of the sample. However a number of interesting factors present themselves including the notion that student age bears little relevance to performance. The one-way analysis of variance for age on performance does not indicate significant levels of interaction. One might have suspected that increased age would result in reduced ability to perform. While there is slight indication of diminished abilities beyond age thirty-six (correlation of -.110), it is minor. When performance is subjected to regression analysis against this age group, it provides no statistically significant predictive capability.

The data does not support those who posit that the older engineer is unable to compete, and to balance home and professional responsibilities with those of academe. While the information does not support a counter argument, it does call such critics into question. If anything, the data offers credence to Knowles (132) and his supporters who contend that older adults bring a wealth of beneficial experience and commitment to the educational process.

Statistically significant differences in performance do develop through interaction with student degree age. While the overall correlation (.119) and general predictive levels are low (1.2% adjusted for degrees of freedom), it is interesting to note that mean graduate quality point averages tend to increase with a rise in degree age. However, this must be considered with caution as the correlation between performance and degree age is only positive for students with B.S. degrees from 6 to 10 years old.

There may be a point where the positive relationship between increasing degree age and performance ceases. Observe that students with degree ages older than eleven exhibit a negative correlation to performance (-.276). Though the predictive value is low (adjusted r squared=5.6) and insignificant, it does hint at a trend.

In summary, while neither age nor degree age offer strong correlations or predictors when measured against performance, results tend to suggest that the academic abilities of older engineers may be underestimated. There is little statistical evidence to warrant the assertion that increased age leads to diminished academic performance.

Analyses of variance do indicate significant performance variations resulting from differences on GRE verbal, quantitative, and analytic tests. In each instance, general correlations were positive. Of the three tests, the quantitative examination offers the strongest predictor. Yet, even it accounts for merely 5.5% of the interaction and has a correlation of only .240. While some might be surprised at this low level, it confirms Gibbons' who also detected low predictive strength for the quantitative test among Stanford engineering students.

On the other hand, quantitative scores did offer the largest "*F*" statistic for significance of the three test scores in analyses of variance, 9.00. This indicates that variation in test scores will likely result in variation in performance.

Among the GREQ subgroups, mean graduate quality point averages recorded were 2.76 (200-500 GREQ), 3.27 (501-600 GREQ), 3.29 (601-700 GREQ) and 3.47 (701-800 GREQ). While the lowest group might be discarded due to a relatively low sample size (11) and wide standard deviation (.799), differences at the other end of the spectrum do seem significant. Note that students in the mid-ranges (501-600 and 601-700) exhibited mean performances of 3.27 and 3.29 respectively. However, those who had GREQ scores in excess of 700 had a mean quality point average nearly two tenths of a point higher. Clearly, those who perform very well on the quantitative test can be expected to do well in graduate engineering programs. However, caution should be exercised in attaching too much significance to this statistic as the GREQ subgroup has small (*r* squared=3.3) predictive value. Again, while the observed variations may be statistically significant, their impact is low. Other factors are at work.

While neither the GRE Verbal nor Analytic tests offered high correlations to graduate performance, 1.85 and 2.00, in both cases, their analyses of variance with performance were both significant to the .01 level. As was the case with the GREQ, the overall relationships of the GREV and GREA were significant but weak. Scheffe tests offered significant differences between those individuals' performance who scored between 501-600 versus those who scored 601-700 on the analytic test. No significant differences in performance were indicated when GREA scores changed from the 601-700 range to above 700.

Similar to those conducted for GRE tests, analyses of variance for stratified undergraduate performance indicate substantial and statistically significant differences in graduate quality grade point average with variations in the undergraduate record. While data offer low statistical correlations and predictive capability, one is struck by the seeming sensitivity of the graduate QPA to changes in levels of the undergraduate QPA. Ignoring the category of students with undergraduate grades from 0 to 2.50 due to a low sample size (N=39), the change in graduate performance from those with undergraduate grades jumping from the 2.51-3.00 level to 3.01-3.50 is .17 (3.19 to 3.36). When the levels change from 3.01-3.50 to 3.51-4.00, there is an additional rise of .13 (3.36-3.49). The mean performance by students with undergraduate quality point averages in the 2.51 to 3.00 range was significantly different (.05 level) from students with undergraduate performance from 3.01 to 3.50.

Taken in toto, neither the variables acting as a whole nor in a stratified mode offer high correlations nor high levels of predictive value. While the data indicate that age and degree age have little relevance on a student's performance, dismissing to a degree the concern that older students "loose it", the reader can infer that those who perform exceptionally well in the GRE verbal and quantitative tests and have very strong undergraduate records will perform in a like manner at the graduate level.

Caution is again urged on assuming too much from the previous inferences. Low correlation correlation coefficients and a heterogeneous sample population allow the above to constitute only the grossest of introductory analyses.

> No statistically significant differences will occur in graduate grade point average between students enrolled on-campus and video-based off-campus students in graduate programs offered by either the Department of Electrical and Computer Engineering or Industrial Engineering/Operations/Research when measured against the following variables: age at the point of initial matriculation; degree age at the point of initial matriculation; scores on the

Graduate Record Examination's verbal, divided into six categories:

To recapitulate, student records were divided into the following categories.

TABLE #17

STUDENT CATEGORIES BY PROGRAM AND LOCATION

Category #1:	On-campus, degree seeking, graduate students enrolled in the Department of Electrical and Computer Engineering
Category #2	Off-campus, degree seeking, graduate students enrolled in the Department of Electrical and Computer Engineering through the Videotape Instructional Program
Category #3	Off-campus non-degree students enrolled in graduate courses offered by the Department of Electrical and Computer Engineering through the Videotape Instructional Program
Category #4	On-campus, degree-seeking, graduate students enrolled in the Department of Industrial Engineering/Operations Research
Category #5	Off-campus, degree-seeking, graduate students enrolled in the Engineering Management concentration of the Department of Industrial Engineering/ Operations Research offered through the Videotape Instructional Program
Category #6	Off-campus non-degree students enrolled in graduate courses offered by the Department of Industrial

Engineering/Operations Research through the Videotape Instructional Program.

RELATIONSHIP OF THE VARIABLES TO STUDENTS DIVIDED INTO ENGINEERING DISCIPLINES: ELECTRICAL AND COMPUTER ENGINEERING AND INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

Before analyzing the relationships of variables to performance within individual categories, attention will be addressed to determining significant differences occurring within the two engineering disciplines: Electrical and Computer Engineering and Industrial Engineering/ Operations Research. Towards this end, one-way analyses of variance were conducted to accept or reject the notions that no differences in mean graduate performance would occur as a result of students studying on or off-campus.

STUDENTS ENROLLED IN GRADUATE COURSES THROUGH THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

TABLE #18

DIFFERENCES IN MEAN GRADUATE QUALITY POINT AVERAGE BY CATEGORY

Description

Grad QPA	All	CAT #1	CAT #2	CAT #3
N	727	219	84	424
Mean QPA	3.25	3.25	3.44	3.21
Median QPA	3.44	3.37	3.50	3.50
StDev	.674	.569	.507	.744

One Way Analysis of Variance

Mean Performance by Student by Category

```
Grad
 QPA                        Individual 95% CI for Mean
                            Based on Pooled StDev
Catgry N   Mean  StDev   --------+---------+---------+--------
  #1   219 3.25  .569     (-------*------)
  #2    84 3.44  .507                (-----------*-----------
  #3   424 3.21  .744    (----*-----)
                         --------+---------+---------+--------
Performance (Grad QPA)         3.24      3.36      3.48
```

F=4.17: Significant at the .05 Level

Note: No significant differences exist between students in category #1 from those in category #2.

Summary: Though differences in student category will significantly account for variations in performance there is no statistically significant difference in mean performance levels between on and off-campus ECE degree students.

TABLE #19

DIFFERENCES IN AGE BY CATEGORY

Description

Age	All	CAT #1	CAT #2	CAT #3
N	1,151	225	86	418
Mean Age	29.51	25.35	30.67	29.51
Median Age	28.00	24.00	29.00	28.00
StDev	7.01	4.15	6.29	6.62

One Way Analysis of Variance

```
                                Individual 95% CI for Mean
Age by                          Based on Pooled StDev
Catgry N    Mean    StDev     --------+---------+---------+--------
  #1   225  25.35   4.15       (---*---)
  #2    86  30.67   6.29                                 (-----*-----
  #3   418  29.51   6.62                               (--*-)
                              --------+---------+---------+--------
Performance (Grad QPA)             26.0       28.0       30.0
F=43.55:  Significant at the .01 Level
```

Summary: A statistically significant variation in age exists between on and off-campus ECE students but not between off-campus degree and off-campus non-degree ECE students. Off-campus ECE students are generally older than on-campus ECE students.

TABLE #20

DIFFERENCES IN DEGREE AGE BY CATEGORY

Description

Degree Age	All	CAT #1	CAT #2
N	1,167	228	87
Mean Degree Age	0.961	2.23	6.78
Median Degree Age	0	1.00	5.00
StDev	3.08	3.69	6.57

One Way Analysis of Variance

```
Degree
Age by                    Individual 95% CI for Mean
                          Based on Pooled StDev
Catgry N   Mean  StDev    --+---------+---------+---------+----
  #1   228 2.23  3.689    (--*--)
  #2    87 6.78  6.569                        (----*----)
                          --+---------+---------+---------+----
Performance (Grad QPA)  2.0       4.0       6.0       8.0
```

F=59.99: Significant at the .01 Level

Summary: The degree age of on-campus ECE degree students is significantly different from off-campus degree students. Off-campus ECE degree students have a higher mean degree age than on-campus ECE students.

TABLE #21

DIFFERENCES IN PERFORMANCE ON GRADUATE RECORD EXAMINATION VERBAL TEST BY CATEGORY

Description

GRE Verbal	All	CAT #1	CAT #2
N	285	208	73
Mean GRE Verbal	524.3	512.3	557.0
Median GRE Verbal	530.0	520.0	570.0
StDev	124.2	124.6	120.0

One Way Analysis of Variance

```
GRE
Verb by                      Individual 95% CI for Mean
Catgry N   Mean   StDev      Based on Pooled StDev
                             -----+---------+---------+---------+-
  #1   208 512.3  124.6      (-----*----)
  #2    73 557.1  119.9                 (---------*--------)
                             -----+---------+---------+---------+-
Performance (Grad QPA)           510       540       570       600
```

F=7.12: Significant at the .01 Level

Summary: Scores on the GRE Verbal test are significantly different among on-campus ECE students when compared to off-campus ECE students. Off-campus ECE students have a higher mean GREV score than do on-campus ECE students.

TABLE #22

DIFFERENCES IN PERFORMANCE ON GRADUATE RECORD EXAMINATION QUANTITATIVE TEST BY CATEGORY

Description

GRE Quantitative	All	CAT #1	CAT #2
N	283	208	73
Mean GRE Quant	682.5	683.3	681.2
Median GRE Quant	690.0	690.0	700.0
StDev	69.4	68.1	73.7

One Way Analysis of Variance

```
 GRE
Quant                          Individual 95% CI for Mean
  by                           Based on Pooled StDev
Catgry N   Mean  StDev  -----+---------+---------+---------+-
  #1  208 683.3  68.1           (---------*---------)
  #2   73 681.2  73.7   (---------------*---------------)
                        -----+---------+---------+---------+-
Performance (Grad QPA)     670       680       690       700
F=0.05:  Not Significant
```

Summary: Scores on the GRE Quantitative test are not significantly different between on and off-campus ECE degree students.

TABLE #23

DIFFERENCES IN GRADUATE RECORD EXAMINATION ANALYTIC TEST
BY CATEGORY

Description

GRE Analytic	All	CAT #1	CAT #2
N	252	186	64
Mean GRE Anal	588.5	582.9	607.0
Median GRE Anal	590.0	590.0	625.0
StDev	107.7	106.3	109.0

One Way Analysis of Variance

```
 GRE
 Anal                        Individual 95% CI for Mean
  by                         Based on Pooled StDev
Catgry N   Mean  StDev   -------+---------+---------+---------
  #1  186 582.9 106.3    (------*-------)
  #2   64 606.7 109.2          (------------*-------------)
                         -------+---------+---------+---------
Performance (Grad QPA)        580       600       620
```

F=2.36: Not Significant

Summary: Scores on the GRE Analytic test are not significantly different between on and off-campus ECE degree students.

TABLE #24

DIFFERENCES IN UNDERGRADUATE QUALITY POINT AVERAGE
BY CATEGORY

Description

Undergraduate QPA	All	CAT #1	CAT #2
N	288	212	72
Mean Ugrad QPA	3.185	3.212	3.097
Median Ugrad QPA	3.230	3.240	3.105
StDev	.402	.367	.479

One Way Analysis of Variance

```
Ugrad
 QPA                           Individual 95% CI for Mean
  by                           Based on Pooled StDev
Catgry N  Mean  StDev   ----------+---------+---------+------
  #1   212 3.212  .367                      (------*------)
  #2    72 3.097  .479   (-----------*-----------)
                        ----------+---------+---------+------
Performance (Grad QPA)        3.705     3.150     3.225
```

F=4.48: Significant at the .05 Level

Summary: A statistically significant differences exists among undergraduate records for on and off-campus ECE degree students. On-campus students evidence a higher mean undergraduate quality point averages than do off-campus students.

The preceeding analyses of variance for Electrical and Computer Engineering students offer a number of interesting points. They also raise a number of questions for future research. Of primary interest is the ANOVA indicating graduate performance being dependent upon category. The mean graduate performance for on-campus degree students is 3.248. Off-campus video-based degree students exhibit a mean graduate average of 3.441. When non-degree students are removed through post-hoc analysis (Scheffe), results support the hypothesis that student category is not a statistically significant variable in accounting for variation in grades. This begins to refute the argument offered by Gibbons and reported by Shanks and others who contend that quality instructional television requires the support of local tutors. This analysis offers that this need not be the case. These statements do not assert that no "human intervention" is required. Indeed, faculty are only a phone call away and interaction is encouraged. Rather, it does support the position that local tutors, although desirable, are not required in an ITV mode to support effective instruction.

While data indicate off-campus degree students in Electrical and Computer Engineering students notes that off-campus degree-seeking video-based students performing at a (mean) higher level than on-campus degree students, the same cannot be said for non-degree off-campus students. These students, similar to off-campus degree students in age (30.51 versus 30.67), perform significantly worse. They offer a mean graduate quality point average of 3.21 compared to 3.44 for off-campus degree students and 3.25 for on-campus degree students.

Even this data presents non-degree student performance in a more positive light than warranted. Recall that the sample of non-degree students was restricted to those individuals who completed courses. This group represents only 50% of the total actually registering for courses. If one assumes that a substantial portion of those students withdrew because they were in danger of failing the course, (133) the group's mean graduate quality point average would be substantially lower. Hypothetically, if those who withdrew, dropped courses, or had records of incomplete, were considered to have failed the course (as no doubt many would have had they not taken the action they had) the mean graduate quality point average would plummet to 1.60. Were on and off-campus degree program drop-outs also included in the sample, the mean performance for those categories would be 3.12 (on-campus) and 3.32 (off-campus).

The poor performance evidenced among non-degree video-based students supports Gibbons' thesis (134) that motivation, as indicated by participation in a degree program, is a requirement for successful participation in video (as well as other forms of) instruction.

Following-up on the issue of students performance, assume that the non-degree drop-outs included at least two subgroups: those who thought they had both the desire and ability to complete a graduate degree program and those just wanting to "brush-up" or get "caught-up" with the state-of-the-art.

While better advising and counseling might preclude many without necessary skills from registering, corporate policies need to be changed to better serve engineers whose motivation is professional development rather than an advanced degree. In many instances, these individuals are forced to enroll in credit courses as only they are covered by the employers' tuition reimbursement policies. Corporate personnel and training officers have long held to the belief that only through the rigors of earning academic can they be assured that learning actually took place. This position forces requires those seeking only professional development to involve themselves in a more theoretical course than they might want or need, one requiring a longer and more structured time commitment, and level of participation (completing tasks associated with getting a grade) beyond that which they were initially willing to offer. The frustrations caused by this less than ideal fit between student needs and course requirements no doubt fosters the higher attrition evidenced among non-degree students.

Liberalized tuition reimbursement policies that fund participation in non-credit courses or in credit courses on an audit or non-credit basis would go far to resolve student frustration and their resulting inordinately high level of failure and attrition.

Returning to the ANOVA's, statistically significant data evidence that off-campus students are approximately five years older than their on-campus counterparts with parallel differences in degree ages while no differences exist between scores on the GRE Quantitative test (686 on-campus versus 681 off-campus).

Interesting, off-campus students had higher verbal and analytic test scores than did the traditional graduate students. On campus enrollees had mean scores of 512 on the verbal and 583 on the analytic test. This compared to mean scores of 557 and 607 respectively by off-campus degree students. The differences between categories for scores on the verbal test proved significant to the .01 level but were insignificant on the analytic test. These result in the following question: do undergraduates with higher verbal and analytic proclivities gravitate more to industry than undergraduates who are not as high in these areas or, do skills in these areas develop once individuals have been in the world of work for a period of time?

On-campus students have higher mean undergraduate grade point averages than do off-campus participants. The difference (3.21 on-campus versus 3.10 off-campus) is significant at the .05 level. Yet, even with lower undergraduate averages, there is no significant variation in mean graduate performance between on and off-campus students. This may partially result from the low predictive value of the undergraduate grades to graduate performance (r squared for on-campus is 3.3%-significant to .01 level; r squared for off-campus is 2.1%-not significant) which furthers the belief in the presence of outside factors. These extraneous variables may well include the off-campus student's work experience. On the other hand, it could argue the benefits derived from use of ITV as an instructional modality. Perhaps acting singularly or in concert age, commitment, and the flexibilities available in mediated instruction (including the ability to study flexibly, stop tapes and repeat unclear sections, etc.) help those with less than stellar undergraduate averages to perform exceptionally well. This also concurs with Gibbons' findings in the Stanford TVI program.

The previous analysis concerned itself with on and off-campus video-based students enrolled in courses offered through the University of Massachusetts' Department of Electrical and Computer Engineering. The following, which can be used for comparative purposes, relates to similarly situated students enrolled in the Department of Industrial Engineering/Operations Research (IEOR). Note that off-campus IEOR degree students participated in a graduate program leading to a Master's Degree in Engineering Management. Even though the degree earned is different, both are accredited and the courses offered in the Management program were the exact same courses offered on-campus.

STUDENTS ENROLLED IN GRADUATE COURSES THROUGH THE DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

TABLE #25

DIFFERENCES IN MEAN GRADUATE QUALITY POINT AVERAGE BY CATEGORY

Description

Grad QPA	All	CAT #4	CAT #5	CAT #6
N	301	83	66	152
Mean QPA	3.22	3.35	3.41	3.06
Median QPA	3.41	3.45	3.50	3.33
StDev	.720	.603	.467	.831

One Way Analysis of Variance

Mean Performance by Student Category

```
                               Individual 95% CI for Mean
                               Based on Pooled StDev
Catgry N   Mean  StDev   ---+---------+---------+---------+---
  #4    83 3.35  .603               (-----*-------)
  #5    66 3.41  .467                  (-------*--------)
  #6   152 3.06  .831     (----*-----)
                         ---+---------+---------+---------+---
Performance (Grad QPA) 3.00      3.20      3.40      3.60
```

F=7.27: Significant at the .01 Level

Note: Post-hoc examination indicates that variation in performance for students in Category #4 and Category #5 was not significantly effected by category.

Summary: While the ANOVA indicates statistically significant variances in performance between the 3 categories, there was no significant variation in performance between on and off-campus degree students in IEOR. Off campus degree students exhibited a slightly higher mean performance than on-campus degree students.

TABLE #26

DIFFERENCES IN AGE BY CATEGORY

Description

Age	All	CAT #4	CAT #5	CAT #6
N	364	85	66	150
Mean Age	30.00	26.19	31.32	30.59
Median Age	28.00	25:00	30.00	29.00
StDev	7.09	5.48	6.00	7.09

One Way Analysis of Variance

```
                                    Individual 95% CI for Mean
Age by                              Based on Pooled StDev
Catgry  N   Mean   StDev   -------+---------+---------+---------
  #4    85 26.19   5.48    (-----*-----)
  #5    66 31.32   6.00                          (-----*------)
  #6   150 30.59   7.09                        (---*----)
                           -------+---------+---------+---------
Performance (Grad QPA)          26.4      28.8      31.2
F=16.05:  Significant at the .01 Level
```

Summary: While significant variations in age exist between on and off-campus IEOR students, they do not exist between off-campus degree and non-degree students. Off-campus IEOR students are generally older than on-campus IEOR students.

TABLE #27

DIFFERENCES IN DEGREE AGE BY CATEGORY

Description

Degree Age	All	CAT #4	CAT #5
N	368	85	67
Mean Degree Age	1.70	3.28	5.10
Median Degree Age	0	2.00	4.00
StDev	4.07	5.47	5.46

One Way Analysis of Variance

```
Degree                         Individual 95% CI for Mean
Age by                         Based on Pooled StDev
Catgry N  Mean  StDev    ---+---------+---------+---------+---
  #4   85 3.28  5.466     (---------*---------)
  #5   67 5.10  5.461                   (----------*---------
                         ---+---------+---------+---------+---
Performance (Grad QPA)    2.4       3.6       4.8       6.0
F=4.17:  Significant at the .05 Level
```

Summary: A statistically significant variation exists in degree age between on and off-campus IEOR graduate students. The degree age of off-campus IEOR students is generally higher than those of on-campus IEOR students.

TABLE #28

DIFFERENCES IN PERFORMANCE ON GRADUATE RECORD EXAMINATION VERBAL TEST BY CATEGORY

Description

GRE Verbal	All	CAT #4	CAT #5
N	138	81	55
Mean GRE Verbal	483.0	468.0	505.0
Median GRE Verbal	490.0	490.0	490.0
StDev	120.0	128.0	105.0

One Way Analysis of Variance

```
GRE                              Individual 95% CI for Mean
Verb by                          Based on Pooled StDev
Catgry N  Mean  StDev  ---+---------+---------+---------+---
  #4   81 468.0 128.1  (--------*--------)
  #5   55 505.3 105.4            (---------*----------)
                       ---+---------+---------+---------+---
Performance (Grad QPA)  450       480       510       540
```

F=3.18: Not Significant

Summary: Even though the mean GRE Verbal score for off-campus IEOR students is higher than for on-campus IEOR students, the difference between the two is not statistically significant.

TABLE #29

DIFFERENCES IN PERFORMANCE ON GRADUATE RECORD EXAMINATION QUANTITATIVE TEST BY CATEGORY

Description

GRE Quantitative	All	CAT #4	CAT #5
N	138	81	55
Mean GRE Quant	632.5	626.7	641.6
Median GRE Quant	630.0	640.0	630.0
StDev	83.0	84.6	81.9

One Way Analysis of Variance

```
 GRE
Quant                      Individual 95% CI for Mean
  by                       Based on Pooled StDev
Catgry N  Mean  StDev   ----------+---------+---------+------
  #4   81 626.7  84.6   (-----------*----------)
  #5   55 641.6  81.9          (-------------*--------------)
                        ----------+---------+---------+------
Performance (Grad QPA)           624       640       656
F=1.05:  Not Significant
```

Summary: Though off-campus IEOR graduate students have a higher mean GREQ score than do on-campus IEOR students, the differences is not statistically significant.

TABLE #30

DIFFERENCES IN GRADUATE RECORD EXAMINATION ANALYTIC TEST BY CATEGORY

Description

GRE Analytic	All	CAT #4	CAT #5
N	131	74	55
Mean GRE Anal	541.0	545.0	537.0
Median GRE Anal	550.0	565.0	540.0
StDev	119.0	124.0	115.0

One Way Analysis of Variance

```
 GRE
 Anal                           Individual 95% CI for Mean
  by                            Based on Pooled StDev
Catgry N   Mean   StDev  --------+---------+---------+--------
  #4   74 544.9 124.3        (------------*------------)
  #5   55 537.3 114.6    (---------------*---------------)
                         --------+---------+---------+--------
Performance (Grad QPA)          520       540       560
```

F=0.13: Not Significant

Summary: On-campus IEOR graduate students have a slightly higher GREA score when compared to that of off-campus IEOR students. The differences are not significant.

TABLE #31

DIFFERENCES IN UNDERGRADUATE QUALITY POINT AVERAGE
BY CATEGORY

Description

Undergraduate QPA	All	CAT #4	CAT #5
N	133	79	52
Mean Ugrad QPA	2.946	3.061	2.750
Median Ugrad QPA	2.950	3.070	2.740
StDev	.457	.381	.498

One Way Analysis of Variance

```
Ugrad
 QPA                           Individual 95% CI for Mean
  by                           Based on Pooled StDev
Catgry N  Mean  StDev  ------+---------+---------+---------+
  #4   79 3.061  .381                       (-----*-----)
  #5   52 2.750  :498  (-------*------)
                       ------+---------+---------+---------+
Performance (Grad QPA)    2.72      2.88      3.04      3.20
```

F=16.43: Significant at the .01 Level

Summary: Statistically significant variations occur between the undergraduate quality point average of on and off-campus campus IEOR graduate students. On-campus students exhibit a higher mean undergraduate average.

A number a similarities are evident from the data describing Industrial Engineering/Operations Research students and Electrical and Computer Engineering students. In both programs, off-campus degree students show higher mean scores on the GRE quantitative and analytic tests than do on-campus students. Note however, that in the Engineering Management program, the mean analytic score for off-campus students falls below the on-campus mean, the opposite for students in Electrical and Computer Engineering.

Similarly, in both programs, off-campus degree students have higher mean graduate averages while non-degree video-based enrollees lag far behind. For the IEOR students, the differences are significant to the .01 level but no doubt reflect the poor showing of the non-degree students (mean scores: Category #4-3.35; Category #5-3.41; Category #6-3.06). Yet, as with the data from Electrical and Computer Engineering, post-hoc (Scheffe) analysis yielded <u>no significant differences in performance among on-campus degree students when compared to those studying off-campus through untutored video</u>.

Looking at the non-degree video students, were those students who dropped or withdrew assumed to have failed and were these grades incorporated into the sample, the variation between IEOR categories would be even more dramatic (respective mean graduate quality point averages: 3.27, 3.35, 2.15).

Personal anecdotal data suggests that less qualified students are initially attracted to the Engineering

Management, viewing it as less rigorous and more attainable. These are often individuals whose backgrounds disqualify them for study in the Electrical and Computer Engineering graduate program. Given the quantitative nature of the program, they quickly discover their error.

In both programs, IEOR and ECE, students' ages and degree ages are markedly similar. On campus students are between 25 and 26 while their off-campus counterparts are 30. In ECE, the on and off-campus mean degree ages are two and six. In IEOR, the means are three and five,

This bears future study in terms of its implication to engineering manpower. Why would a thirty year-old engineer move so quickly away from engineering and seek a management degree? While there is no doubt that management requirements are placed early on young engineers, the question remains whether the employer would be better served with a more highly trained engineer than a degreed manager? The issue is complicated by data suggesting less qualified technical engineers, as indicated by undergraduate quality point averages, seeking the Engineering Management degree. Note that the mean undergraduate quality point average for Engineering Management degree students is 2.75 while for the Electrical and Computer Engineering off-campus graduate student, it approaches 3.21. Further, in all three tests on the Graduate Record Examination, Engineering Management students have lower mean scores than their ECE counterparts. In this instance, the oft-noted saw, "make an engineer a manager and you lose a good engineer and gain a lousy manager," might be amended to say, "make a lousy engineer a manager . . ." One might question the impact that this has on the long-term practices prevalent in American industry.

Are we to assume from this data that less qualified technical staff are making engineering decisions impacting upon America's long-term high technology future? This crucial issue also bears future analysis.

ANALYSIS OF PERFORMANCE AND INTERACTION OF VARIABLES BY CATEGORY

The following analyses will focus upon the interactionof individual variables (in both gross and stratified modes) upon specific student categories. Results will provide detailed descriptions, comparisons, and predictive values of each variable upon performance as measured against the graduate quality point average. It offers the finest level of analysis relating the variables to performance in this study.

The following table of correlations and means is provided for descriptive purposes. It summarizes the categorical characteristics that will be discussed in detail in the following report of the research.

TABLE #32

CORRELATIONS AND MEANS BY CATEGORY

	CAT 1	CAT 2	CAT 3	CAT 4	CAT 5	CAT 6
MEAN GRADUATE QUALITY POINT AVERAGE:	3.25	3.44	3.21	3.34	3.41	3.06
AGE:						
Sample Size	219	86	424	85	66	152
Mean	25.3	30.7	30.5	26.2	31.3	31.1
Corr. to Grad QPA	.161	.102	.054	-.338	-.122	.052
DEGREE AGE:						
Sample Size	228	87		85	67	
Mean	2.23	6.78		3.28	5.10	
Corr. to Grad QPA	.226	.130		-.307	.105	
GRE VERBAL:						

Sample Size	208	73	81	55
Mean	512	557	468	505
Corr. to Grad QPA	.133	.217	.057	.297

GRE QUANTITATIVE:

Sample Size	208	73	81	55
Mean	683	681	627	642
Corr. to Grad QPA:	.182	.316	.366	.303

GRE ANALYTIC:

Sample Size	186	64	74	55
Mean	583	607	545	537
Corr. to Grad QPA	.110	.076	.228	.362

UNDERGRADUATE QUALITY POINT AVERAGE:

Sample Size	212	72	79	52
Mean	3.21	3.10	3.07	2.74
Corr. to Grad QPA	.250	.144	.246	.062

CATEGORY #1

ON CAMPUS DEGREE STUDENTS
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

The following statistics describe the interaction of variables upon on-campus graduate degree students in the University of Massachusetts' Department of Electrical and Computer Engineering. On average, full-time resident graduate students are twenty-five years of age and two years beyond their undergraduate program where they earned a mean quality point average of 3.21. Their GRE verbal, quantitative, and analytic tests scores are 512, 683, and 583. Overall performance in graduate school is 3.25 on a 4.0 scale.

No independent variable offers high correlation to graduate quality point average. The highest among these are degree age (.226) and cumulative undergraduate average (.250). When performance is regressed against age, one notes a predictive capacity of only 2.6% (2.1 when corrected for degrees of freedom). Yet, for on-campus ECE students, age was significant to the .05 level.

When subjected to analysis of variance one observes that variations in performance resulting from age is significant to the .05 level. Data also indicate that the oldest group of students (31 or older) performed at a higher level then did their younger peers. In fact of the three age levels (20-25, 26-30, 31 and older), the best correlation to performance was in this older group (.245). A slightly negative correlation showed-up in the middle group, which also evidenced the worst mean performance among the three.

Caution should be exercised in reading too much into these data, particular when confronted with the meager correlations and small predictive power of the variable. On the other hand, it offers further support to the argument that increasing student age does not necessarily result in diminished academic performance. Unfortunately, the data does not indicate upper limits for this position. For instance, at what point in age, if any, would performance drop-off. Regardless, it does support Knowles who contends that adults, committed to a program, bring a great deal to it.

Given the correlation of age to degree age of students in this category (.864), it is not surprisingly that degree age data support the contentions noted above. The analysis of variance offered that students with degrees five year old or older perform the best among the three groups. Students with degrees from two to four years old, on average, performed the worst. The correlation of degree age to student performance in this group was -.203 while the correlation for students in the oldest group was .397. Again, note the caution that degree age predicted only 5.7% (4.7% adjusted for degrees of freedom) of the variation and that this proved statistically insignificant.

Little relationship existed between performance and scores on the Graduate Record Examination's verbal and analytic tests. Regression analysis offered overall predictiveness of 1.8% (1.3% adjusted for degrees of freedom), statistically insignificant, in describing the relationship between the verbal test and graduate performance. An _r_ squared for predictiveness of only 1.2% (0.7% when corrected for degrees of freedom) was evidenced on the analytic test's regression model.

Surprisingly, performance and the quantitative portion of the GRE, while significant to the .01 level, accounted for only 3.3% of the sample (1.3% adjusted). The correlation between the test and performance was only .182. Recall that Gibbons was also surprised with the low relationship of Stanford performance to the GREQ. He noted 11% predictive capability. Again, other factors are at work in affecting performance.

Data from post-hoc analyses did indicate statistically significant (to .05 levels) variations in performance between students who scored from 601 to 700 on the quantitative test versus those scoring above 701. The mean graduate average for students in the former group was 3.14. Students with scores above 701 on the GREQ achieved a mean performance level of 3.40. While there are significant differences between the two groups, in neither instance is the interaction of the GREQ upon performance statistically significant.

Undergraduate QPA was the variable offering the strongest predictive power of prediction. Significant to the .01 level, the r squared was 6.3% of the population (5.5% adjusted). While significant, this still accounts for a small proportion of the variation.

The analysis of variance offered significant differences in performance accrued from differences in the undergraduate QPA (.05 level). However, post-hoc analysis evidenced no significant variation in performance among enrollees with an undergraduate record of 3.01-3.50 (mean graduate QPA of 3.29) versus those with an undergraduate record from 3.51 to 4.00 (mean graduate grade of 3.43).

None of the variables acting individually indicated substantial predictive capability. A step-wise regression was conducted to determine if better prediction resulted from a combination of variables. The results of this analysis pointed to undergraduate quality point average, degree age, and GREQ score as offering the best joint predictor, 16.15%. Unfortunately, this is still quite low, leading to questions for future analyses.

The previous analyses were offered in light of the following data.

ON-CAMPUS GRADUATE STUDENTS
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

TABLE #33

SUMMARY DESCRIPTION

Category #1	Age	Degree Age	Graduate Verbal	Record Quant	Exam Analy	Ugrad QPA	Grad QPA
Sample Size	225	228	208	208	186	212	219
Mean	25.35	2.23	512.3	683.3	582.9	3.212	3.249
Median	24.00	1.00	520.0	690.0	590.0	3.240	3.370
StDev	4.15	3.69	124.6	68.1	106.3	.367	.569

INTERACTIVE CORRELATIONS

Category #1	Age	Degree Age	Graduate Verbal	Record Quant	Exam Analy	Ugrad QPA
Degree Age	.864					
GRE Verb	.345	.332				
GRE Quant	.051	.112	.420			
GRE Anal	.144	.203	.657	.577		
Ugrad QPA	-.147	-.165	-.031	.015	.015	
Grad QPA	.161	.226	.133	.182	.110	.250

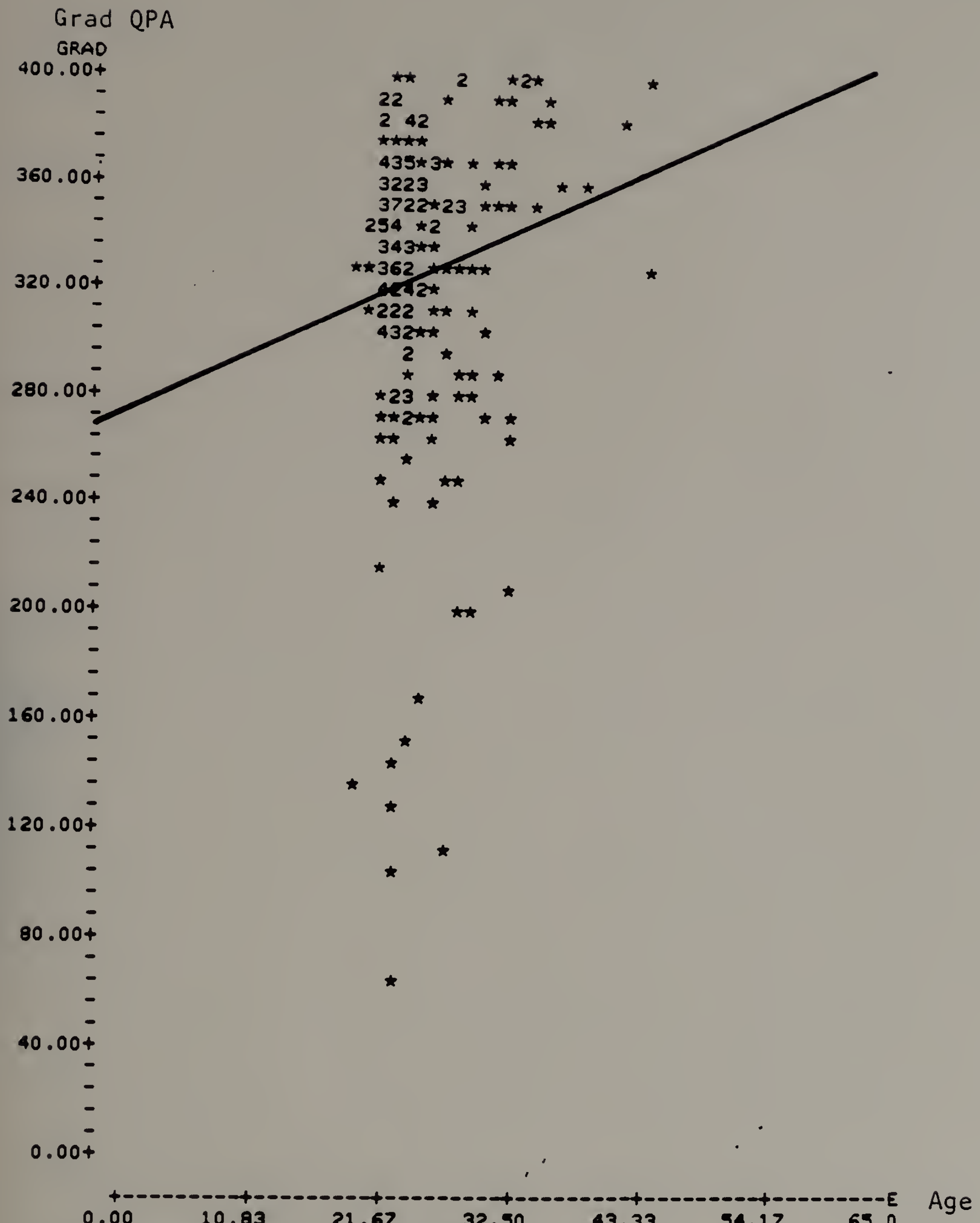
TABLE #34

AGE AND PERFORMANCE

Gross Regression Analysis

Sample Size	219
Formula:	Grad = 269 + (2.23) (AGE)
r squared:	2.6
r squared Adjusted for DF:	2.1
F=5.67	
Significant to the .05 level	

PLOT #8
AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Graduate QPA = 269 + 2.23 Age
Correlation: .161
r squared: 2.6%

TABLE #34A

Description: Age (Stratified)

Category #1	ALL	Age 20-25	Age 26-30	Age 31 +
	Grad Quality Point Ave for			
Sample Size	219	147	46	23
Mean	3.248	3.234	3.145	3.569
Median	3.370	3.330	3.255	3.700
StDev	.569	.567	.564	.521
Corr. to Grad QPA	.161	.068	-.014	.245
_r_ squared	2.6	0.5	0	6.0
_r_ squared Adj DF	2.1	0	0	1.5
_F_=	5.68	0.66	0.01	1.34
Level of Sig	.05	No	No	No

Analysis of Variance: Age as a Determinent for Performance

```
              Mean
              Grad          Individual 95% CI for Mean
                            Based on Pooled StDev
 Age     N    QPA   StDev   ------+---------+---------+---------+
20-25  147  3.234   .567          (---*---)
26-30   46  3.145   .564    (------*------)
31 +    23  3.569   .521                  (---------*--------)
                            ------+---------+---------+---------+
Performance (Grad QPA)          3.12      3.36      3.60      3.84
F=4.58:  Significant at the .05 Level
```

Note: Significant differences exist at the .01 level between variations in performance for students aged 26-30 versus those 31 years old or older.

Summary: Age is a significant though low-level predictor of variation in performance among on-campus ECE graduate students. Variation in student age is statistically significant in accounting for variations in performance. Significant differences in performance were noted between students aged 26-30 from those older than thirty.

TABLE #35

DEGREE AGE AND PERFORMANCE

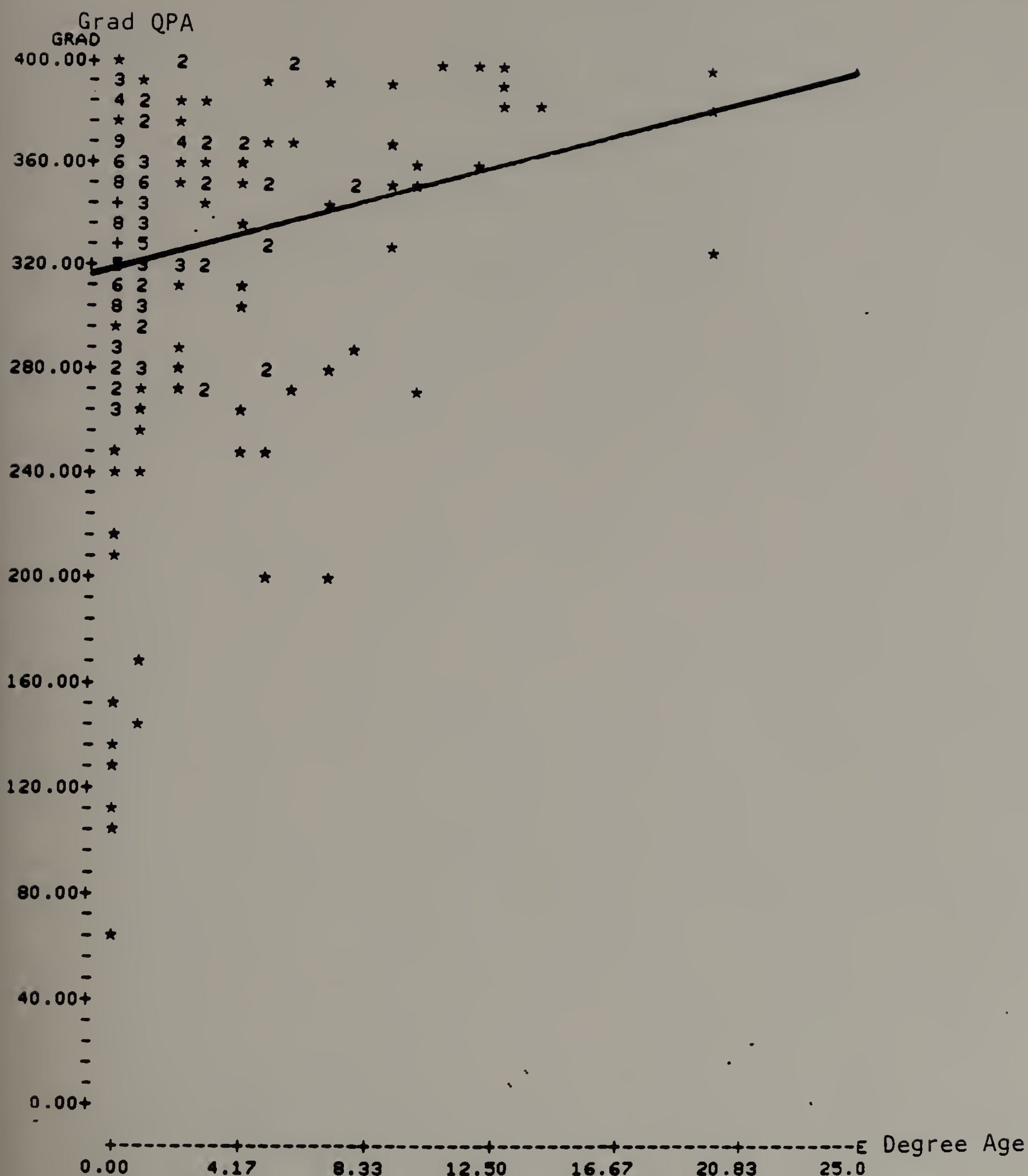
Gross Regression Analysis

Sample Size	219
Formula:	Grad = 317 + (3.47) (Deg Age)
r squared:	5.1
r squared Adjusted for DF:	4.7

F=4.26
Significant to the .05 level

PLOT #9

DEGREE AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Graduate QPA = 317 + 3.47 Degree Age
Correlation: .226
r squared: 5.1%

TABLE #35A

Description: Degree Age (Stratified)

Category #1	ALL	Grad Quality Point Ave for Degree Age 0-1	Degree Age 2-4	Degree Age 5 +
Sample Size	219	147	37	38
Mean	3.248	3.169	3.368	3.430
Median	3.370	3.330	3.500	3.525
StDev	.569	.597	.402	.552
Corr. to Grad QPA	.226	.019	-.203	.397
_r_ squared	5.1	0	4.1	15.8
_r_ squared Adj DF	4.7	0	1.4	13.4
_F_	11.65	0.05	1.50	6.75
Level of Sig	.01	No	No	.05

Analysis of Variance:
Degree Age as a Determinent for Performance

```
            Mean          Individual 95% CI for Mean
Degree      Grad          Based on Pooled StDev
 Age    N   QPA    StDev  --------+---------+---------+--------
 0-1   144 3.169   .597   (-----+-----)
 2-4    37 3.368   .402         (----------*-----------)
 5 +    38 3.430   .552            (----------*-----------)
                          --------+---------+---------+--------
Performance (Grad QPA)        3.20      3.36      3.52
```

_F_=4.26: Significant at the .05 Level

Summary: Degree age is a significant but minor predictor of variation in performance. Significant variations in performance result from variations in degree age.

TABLE #36

GRADUATE RECORD EXAMINATION VERBAL TEST AND PERFORMANCE

Gross Regression Analysis

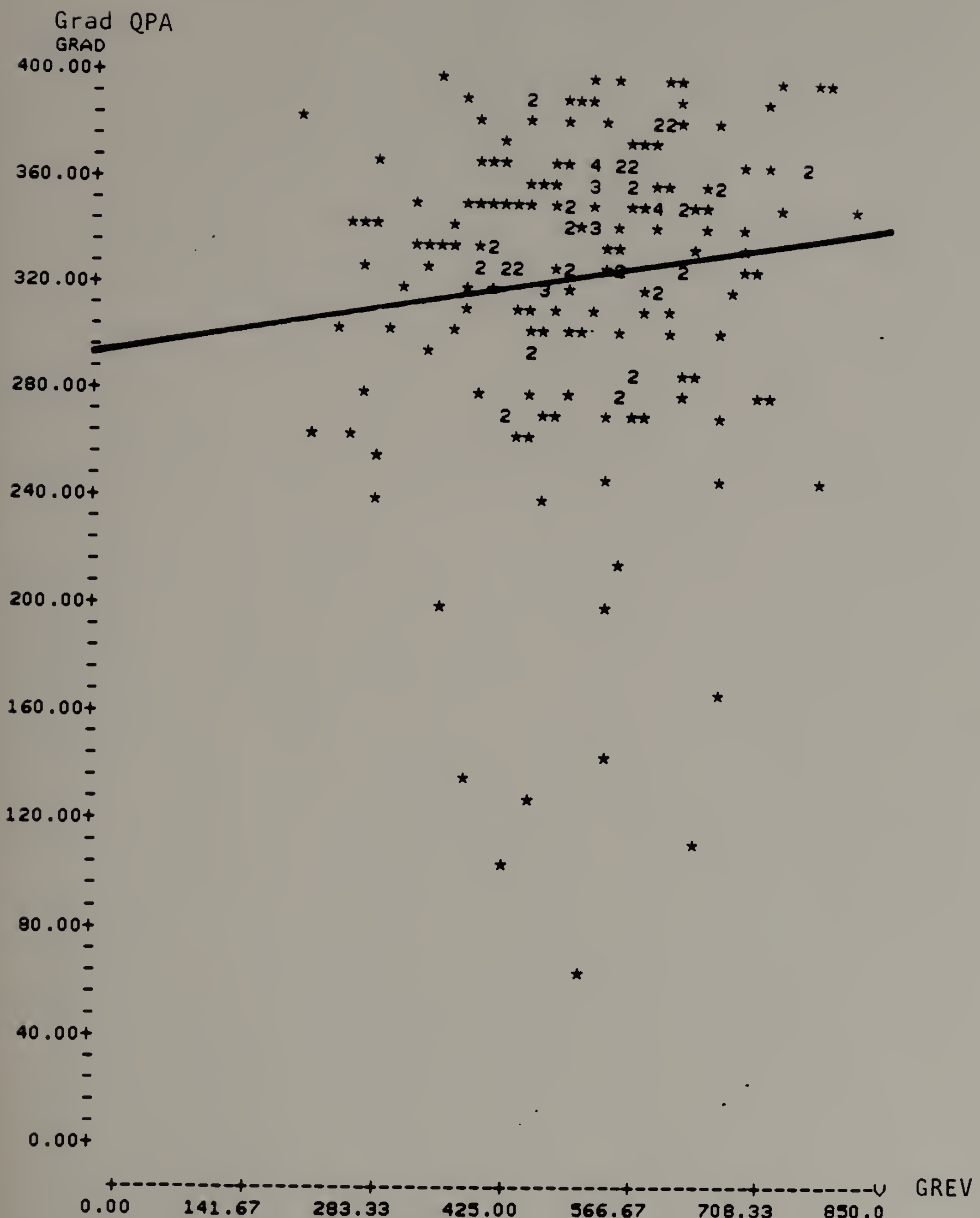
Sample Size	219
Formula:	Grad = 295 + (0.0608) (GREV)
r squared:	1.8
r squared Adjusted for DF:	1.3

F=0.91

Not Significant

PLOT #10

GRE VERBAL VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Graduate QPA = 295 + 0.0608 GREV
Correlation: .133
r squared: 1.8%

TABLE #36A

Description: GRE Verbal Test (Stratified)

	Grad Quality Point Ave for					
Category #1	ALL	GRE Verbal 200-400	GRE Verbal 401-500	GRE Verbal 501-600	GRE Verbal 601-700	GRE Verbal 701-800
Sample Size	219	37	55	61	34	13
Mean	3.248	3.178	3.206	3.298	3.282	3.486
Median	3.370	3.270	3.250	3.500	3.420	3.650
StDev	.569	.527	.545	.600	.617	.140
Corr. to Grad QPA	.133	.093	.117	.128	-.201	.196
r squared	1.8	0.9	1.4	1.7	4.0	3.8
r squared Ad DF	1.3	0	0	0	1.0	0
F	3.56	0.31	0.74	0.99	1.34	0.44
Level of Sig	No	No	No	No	No	No

Analysis of Variance:
Graduate Record Examination Verbal as a Determinent for Performance

```
              Mean              Individual 95% CI for Mean
 GRE          Grad              Based on Pooled StDev
Verbal  N     QPA    StDev    ------+---------+---------+---------+
200-4/  37  3.178    .527      (------+-------)
401-5/  55  3.206    .545        (------*-----)
501-6/  61  3.298    .600            (-----*-----)
601-7/  34  3.282    .617          (-------*-------)
701-8/  13  3.486    .504             (------------*------------)
                              --------+---------+---------+---------+
Performance (Grad QPA)     3.12      3.36      3.60      3.84
F=0.91:  Not Significant
```

Summary: The GRE Verbal test is not a significant predictor of performance among ECE degree students. Variations in the GREV do not result in statistically significant differences in graduate performance among on-campus ECE students.

TABLE #37

GRADUATE RECORD EXAMINATION QUANTITATIVE TEST AND PERFORMANCE

Gross Regression Analysis

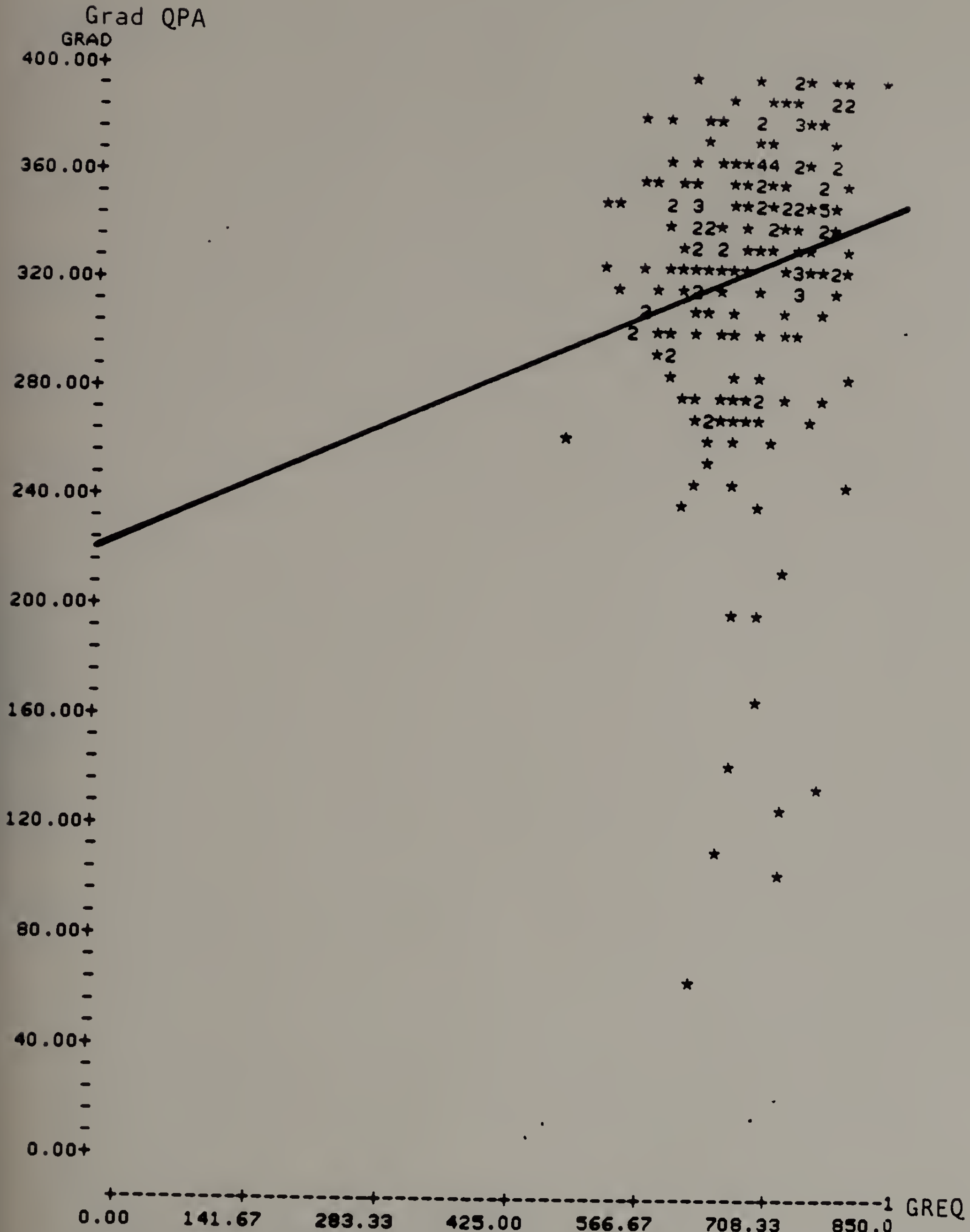
Sample Size	219
Formula:	Grad = 222 + (0.152) (GREQ)
r squared:	3.3
r squared Adjusted for DF:	2.8

F=4.62

Significant to the .01 level

PLOT #11

GRE QUANTITATIVE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Graduate QPA = 222 + 0.152 GREQ
Correlation: .182
r squared: 3.3%

TABLE #37A

Description: GRE Quantitative Test (Stratified)

Category #1	ALL	Grad Quality Point Ave for GRE Quant 200-600	GRE Quant 601-700	GRE Quant 701 +
Sample Size	219	26	90	84
Mean	3.248	3.260	3.136	3.393
Median	3.370	3.235	3.250	3.500
StDev	.569	.317	.610	.558
Corr. to Grad QPA	.182	.196	.084	.148
r squared	3.3	3.8	0.7	2.2
r squared Ad DF	2.8	0.0	0.0	1.0
F	6.79	0.96	0.62	1.83
Level of Sig	.01	No	No	No

Analysis of Variance:
Graduate Record Examination Quantitative
as a Determinent for Performance

```
           Mean
 GRE       Grad              Individual 95% CI for Mean
                             Based on Pooled StDev
Quant  N   QPA    StDev   -----+---------+---------+---------+-
200-6/ 26  3.260  .317      (---------------*---------------)
601-7/ 90  3.136  .610     (-------*-------)
701 +  84  3.393  .558                          (-------*--------)
                          -----+---------+---------+---------+-
Performance (Grad QPA)      3.08      3.22      3.36      3.50
F=4.62:  Significant at the .05 level
```

Note: Significant differences to the .05 level between performance of student with GRE verbal scores in the range of 601-700 from those with GRE verbal scores from 701 up.

Summary: The GRE Quantitative test is a significant but low level predictor of on-campus ECE graduate student performance. Statistically significant variations occur from variations in the GREQ scores among this category of student. Students scoring above 700 on the GREQ perform significantly differently from those with test scores ranging from 601 to 700. Students scoring above 701 on the GREQ have a mean performance of 3.34, while students with test scores from 601 to 700 have a mean performance level of 3.14.

TABLE #38

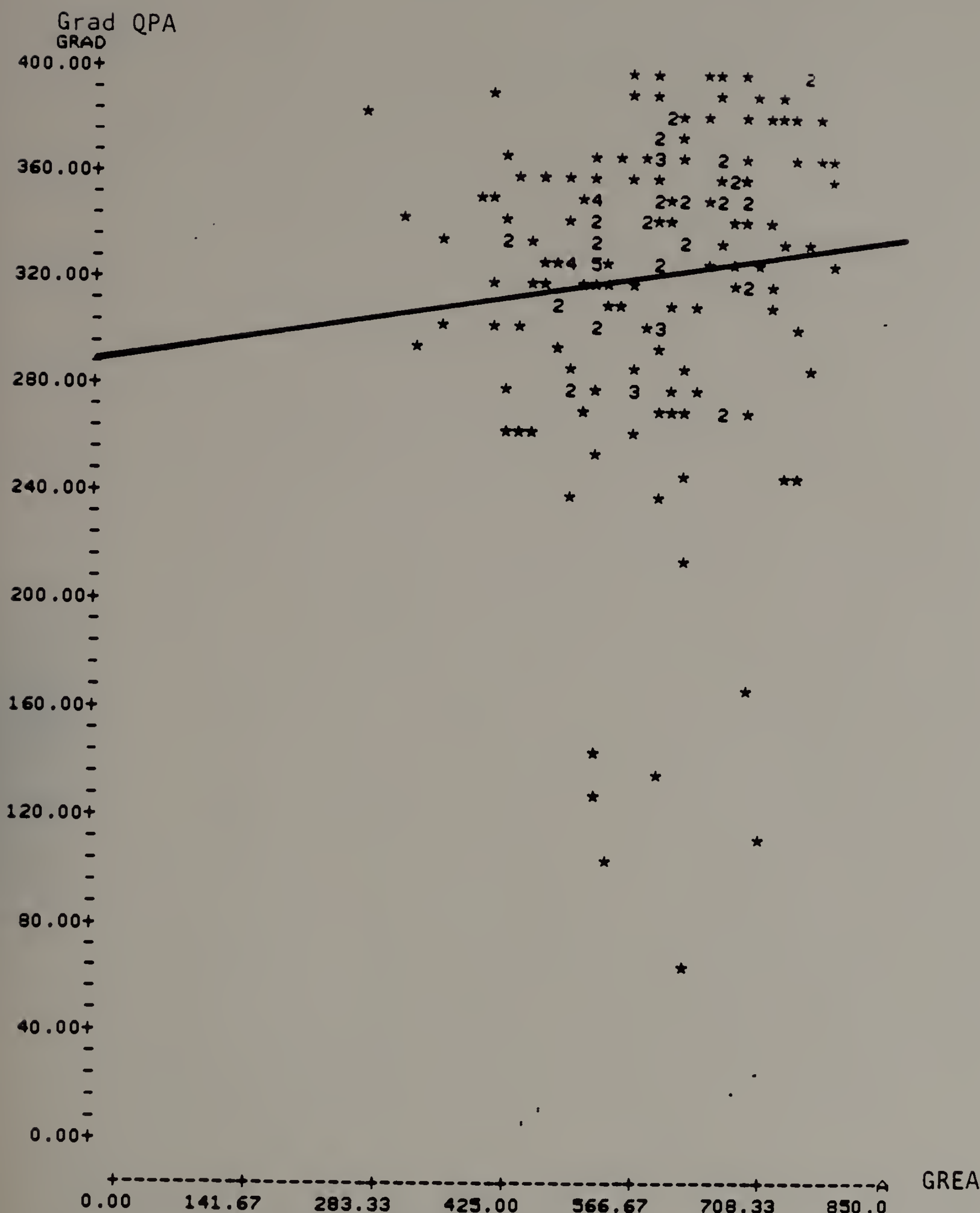
GRADUATE RECORD EXAMINATION ANALYTIC TEST AND PERFORMANCE

Gross Regression Analysis

Sample Size	219
Formula:	Grad = 289 + (0.0590) (GREA)
_r_ squared:	1.2
_r_ squared Adjusted for DF:	0.7
_F_=0.87	
No Significance	

PLOT #12

GRE ANALYTIC VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Graduate QPA = 289 + 0.0590 GREA
Correlation: .110
r squared: 1.2%

TABLE #38A

Description: GRE Analytic Test (Stratified)

		Grad Quality Point Ave for			
Category #1	ALL	GRE Analy 0-500	GRE Analy 510-600	GRE Analy 601-700	GRE Analy 701 +
Sample Size	219	39	64	51	24
Mean	3.248	3.199	3.169	3.287	3.361
Median	3.370	3.250	3.255	3.500	3.530
StDev	.569	.345	.608	.614	.654
Corr. to Grad QPA	.110	-.287	.113	.145	.260
r squared	1.2	8.2	1.3	2.1	6.8
r squared Ad DF	0.7	5.8	0	0.1	2.5
F	2.16	3.32	0.81	1.05	1.60
Level of Sig	No	No	No	No	No

Analysis of Variance:
Graduate Record Examination Analytic
as a Determinent for Performance

```
          Mean            Individual 95% CI for Mean
 GRE      Grad            Based on Pooled StDev
Analy  N  QPA    StDev    --+---------+---------+---------+----
0-500  39 3.199  .345      (----------*----------)
501-6/ 64 3.169  .608      (--------*--------*
601-7/ 51 3.287  .614             (--------*---------)
701 +  24 3.361  .654             (-------------*-------------)
                          --+---------+---------+---------+----
Performance (Grad QPA) 3.04      3.20      3.36      3.52
F=0.87:  Not Significant
```

Summary: Scores on the GRE Analytic test offer no predictive value for performance for on-campus ECE students. Though mean graduate performance generally rises with higher scores on the GREA, the variations are not statistically significant.

TABLE #39

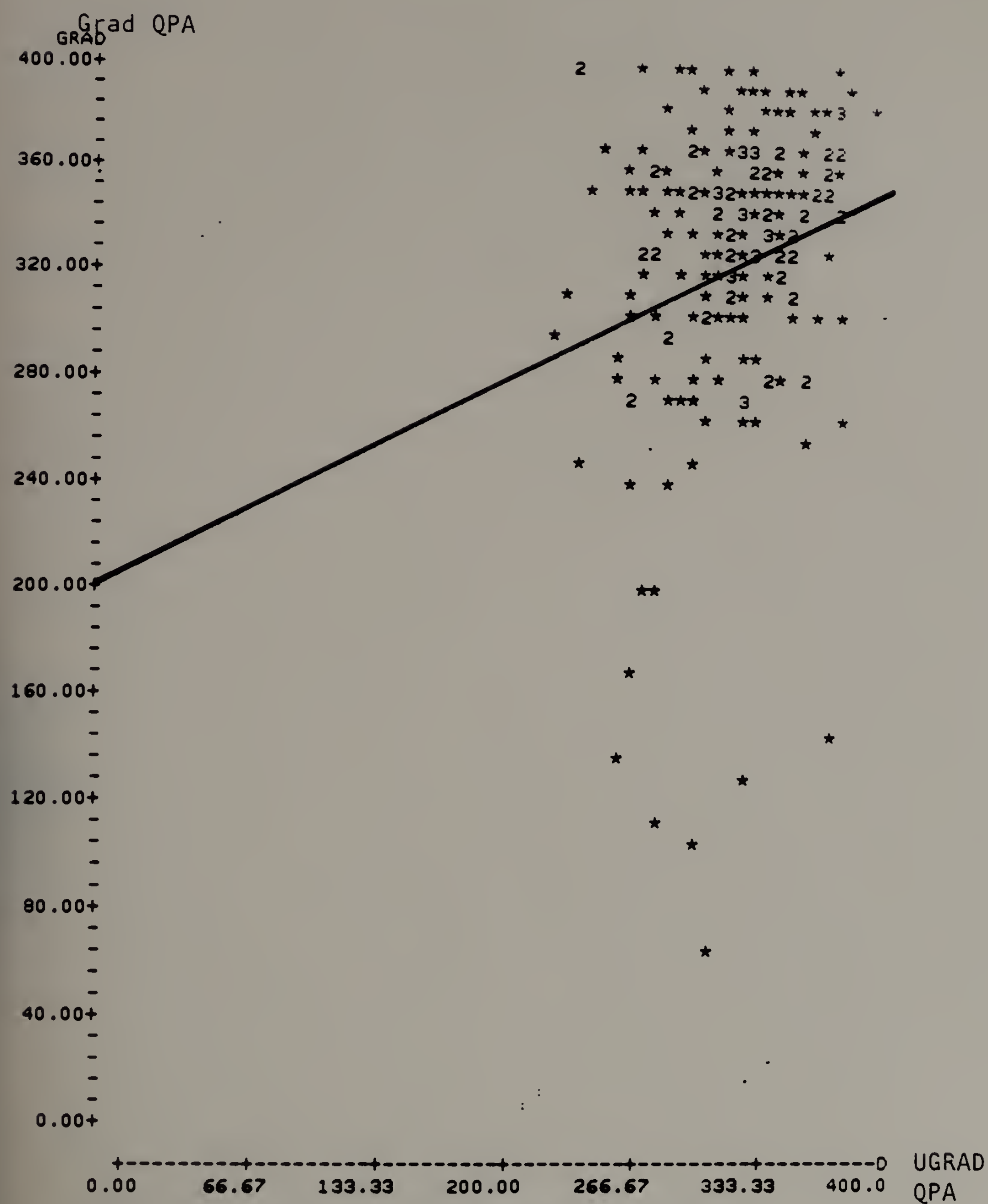
UNDERGRADUATE QUALITY POINT AVERAGE AND PERFORMANCE

Gross Regression Analysis

Sample Size	219
Formula:	Grad = 201 + (0.389) (UGRAD)
_r_ squared:	6.3
_r_ squared Adjusted for DF:	5.8
_F_=5.18	
Significant to the .01 level	

PLOT #13

UNDERGRADUATE QPA VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Graduate QPA = 201 + 0.389 Undergraduate QPA
Correlation: .250
r squared: 6.3%

TABLE #39A

Description: Undergraduate QPA (Stratified)

Category #1	ALL	Grad Quality Point Ave for Ugrad QPA 0-3.00	Ugrad QPA 3.01-3.50	Ugrad QPA 3.51-4.00
Sample Size	219	52	105	46
Mean	3.248	3.081	3.290	3.429
Median	3.370	3.180	3.330	3.500
StDev	.569	.649	.520	.467
Corr. to Grad QPA	.250	.039	.164	.197
_r_ squared	6.3	0.2	2.7	3.9
_r_ squared Ad DF	5.0	0	1.7	1.7
_F_	13.43	0.08	2.84	1.77
Level of Sig	.01	No	No	No

Analysis of Variance:
Undergraduate Quality Point Average
as a Determinent for Performance

```
              Mean          Individual 95% CI for Mean
Ugrad         Grad          Based on Pooled StDev
 QPA     N    QPA     StDev----+---------+---------+---------+--
0-3.00    52 3.081   .649 (------*------)
3.01/50 105 3.290   .520              (-----*----)
3.51/400 46 3.429   .467                    (------*-------)
                          ----+---------+---------+---------+--
Performance (Grad QPA)  3.00       3.20      3.40      3.60
```

_F_=5.18: Significant at the .01 Level

Note: A statistically significant variation exists between students with an undergraduate average from 0 to 3.00 versus those with an undergraduate record of 3.51 to 4.00. No significance in variation is observed between students with an undergraduate record of 3.01-3.50 and those with a record ranging from 3.51 to 4.00

Summary: The undergraduate quality point average for on-campus ECE students is a significant but low-level predictor of graduate performance. Variations in undergraduate records are statistically significant in accounting for changes in graduate performance. A significant variation in performance is noted for students with an undergraduate record of up to 3.00 against those with an undergraduate range of above 3.51. There is no difference between students with an undergraduate record from 3.01 to 3.50 and those with a record above 3.51.

CATEGORY #2

OFF-CAMPUS VIDEO-BASED DEGREE STUDENTS DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Off-campus VIP degree students in the Electrical and Computer Engineering Master's program are normally thirty-one years-old and have been out of school for seven years. The mean age of their B.S. degree is five years older than those of the on-campus students. Off-campus degree students have higher mean scores than on-campus students on the GRE Verbal (557 versus 512) and Analytic tests (607 versus 583) while the mean difference between the two groups on the Quantitative test is only 2 points (off-campus students: 681; on-campus students 683). Category #2 students have lower mean undergraduate quality point averages (3.08 versus 3.21) while their performance in the graduate program is higher (3.44 versus 3.25).

Age again proves not to be a significant variable. The analysis of variance determining difference in performance based upon age was insignificant.

Degree age proved similarly inconsequential with a predictive value of only 1.1% (0% corrected for degrees of freedom). While the ANOVA seeking differences in performance based upon age of the undergraduate degree proved insignificant the trend showing better performance with increased degree age continued. Mean performance for students the degrees younger than three years-old was 3.39. Mean graduate quality point averages of 3.41, 3.48, and 3.54 were found for individuals with undergraduate engineering degrees from four to five, six through ten, and eleven or more years old. Again note that this data proved statistically insignificant and that as a result, post-hoc tests could not be run to prove significant differences among the degree age groups.

Given a .861 correlation between age and degree age, one would expect to find this (statistically insignificant) trend existing between a student's age and quality point average. Indeed this is the case, for we have generally found increased performance with increased age. Note the following.

TABLE #40

Off-Campus ECE Degree Students
Mean Graduate QPA by Age Group

Age Group	Mean Graduate QPA
20-25	3.27
26-30	3.15
31-35	3.57
36 +	3.50

While insignificant, we continue to find strong performance among older students, again validating Malcolm Knowles. It would clearly indicates that older students are bringing a positive combination of commitment and technical expertise gained on the job to the educational program.

Off-campus students paralleled on-campus enrollment in the Graduate Record Examination with a trend indicating higher graduate performance with higher scores on the verbal test. Though these trends were in parallel, they were statistically insignificant.

Similar trends do not exist between performance and the Analytic test. Students scoring from 601 to 700 on the test had a mean average of 3.50. Students with a mean score above 701 on the GREA had a quality point average of 3.41.

The relationship between performance and the quantitative test was significant (.01 level). The regression analysis offered predictive power for 10.0% of the sample (8.7% corrected for degrees of freedom) and was significant to the .05 level.

The ANOVA determining relationship between the GREQ and performance also proved significant to the .05 level offering a clear indication that some relationship existed between it and performance. While the Scheffe did not indicate statistically significant differences, the relationships' sensitivity is indicated by the fact that as mean test scores increased from 200-600, to 601-700, and from 701 to 800, so did graduate quality point averages (3.10, 3.46, and 3.57 respectively).

The impact of the quantitative test upon grades is most dramatically noticed among those students who scored above 700. Within this group, the correlation between test performance and grades was .433 with a predictive value of 18.7% (16.0 adjusted). This was significant to the .05 level. While this would not be unanticipated, one would question why students in the next lower group, scoring from 601 to 700 on the quantitative test, would find a correlation to performance of -.369 (r squared of 13.6% and 10.0% corrected)! Though statistically insignificant, it also raises question for follow-up research.

The relationship of undergraduate to graduate performance for off-campus ECE students did not offer strong predictive power when regressed for graduate performance (*r* squared= 2.1%, 0.6% adjusted for degrees of freedom-insignificant). This differed substantially from on-campus students where the predictive power, though still low, was significant for 6.3% of the population (5.8% corrected for degrees of freedom).

The analysis of variance proved inconclusive for this variable's interaction with graduate performance. One finds a high (but insignificant) correlation (.367) among those individuals who had a mean undergraduate cumulative average from 3.51 to 4.00 and graduate performance. Students with undergraduate records of 3.01 to 3.50 exhibited a correlation to graduate performance of only .076.

With the low and insignificant relationships recorded between the variables and graduate performance, it was not surprising to note that the stepwise regression only offered the quantitative GRE test as a considered variable.

The previous arguments were offered in light of the following data.

OFF-CAMPUS VIDEO-BASED DEGREE PROGRAM GRADUATE STUDENTS
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

TABLE #41

SUMMARY DESCRIPTIONS
OFF-CAMPUS ECE GRADUATE STUDENTS

Category #2	Age	Degree Age	Graduate Verbal	Record Quant	Exam Analy	Ugrad QPA	Grad QPA
Sample Size	86	87	73	73	64	72	84
Mean	30.67	6.78	557.0	681.2	607.0	3.079	3.441
Median	29.00	5.00	570.0	700.0	625.0	3.105	3.500
StDev	6.26	6.57	120.0	73.7	109.0	.479	.507

INTERACTIVE CORRELATIONS

Category #2	Age	Degree Age	Graduate Verbal	Record Quant	Exam Analy	Ugrad QPA
Degree Age	.861					
GRE Verb	.256	.246				
GRE Quant	-.030	-.014	.516			
GRE Anal	-.141	-.066	.570	.660		
Ugrad QPA	.046	.029	-.019	.178	.051	
Grad QPA	.102	.130	.217	.316	.076	.144

TABLE #42

AGE AND PERFORMANCE

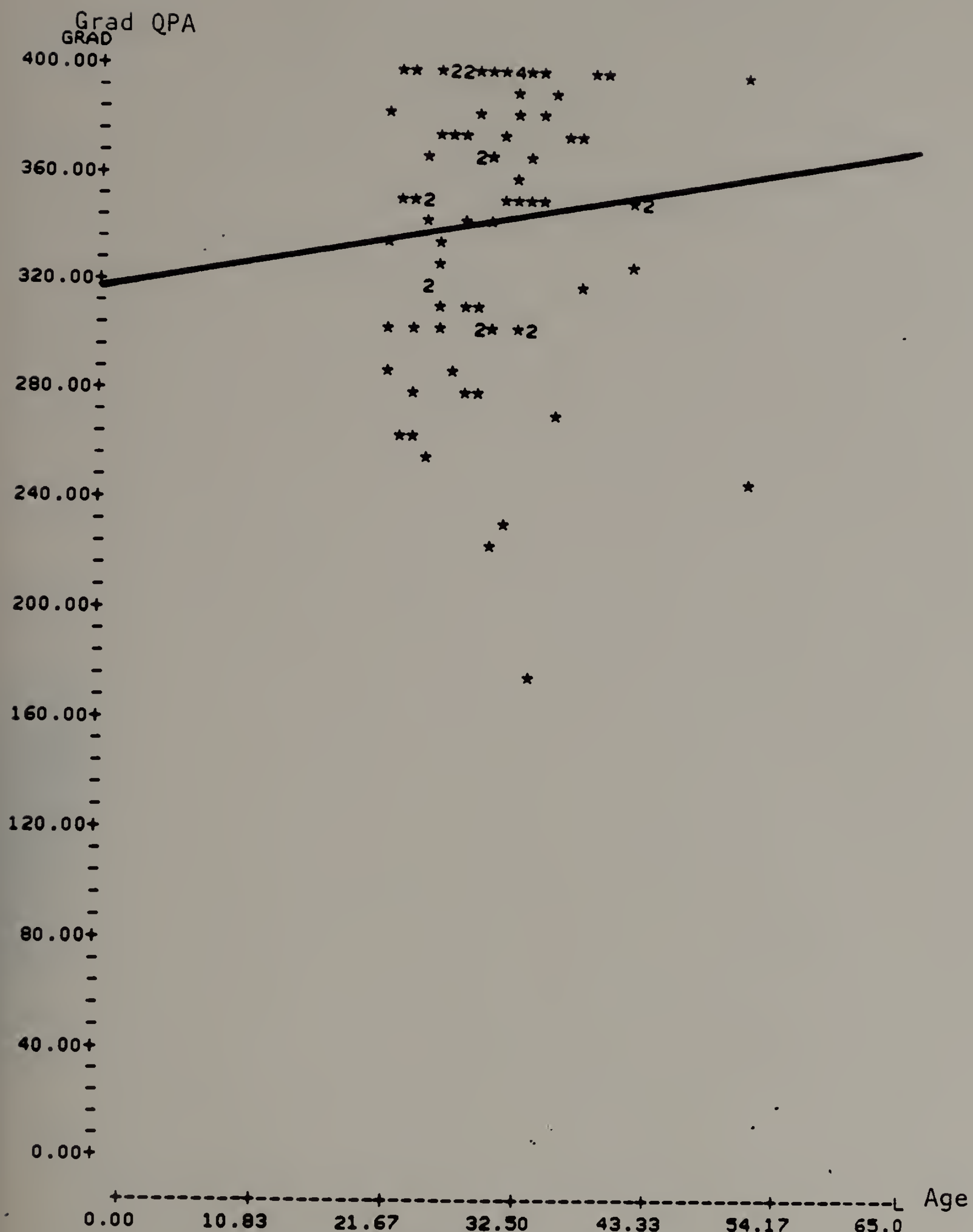
Gross Regression Analysis

Sample Size	83
Formula:	Grad = 318 + (0.833) (Age)
_r_ squared:	1.0
_r_ squared Adjusted for DF:	0

_F_=0.98
Not Significant

PLOT #14

AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #2



Graduate QPA = 318 + 0.833 Age
Correlation: .102
r squared: 1.0%

TABLE #42A

Description: Age (Stratified)

Category #2	Grad Quality Point Ave for ALL	Age 20-25	Age 26-30	Age 31-35	Age 36 +
Sample Size	84	19	29	22	13
Mean	3.441	3.272	3.440	3.530	3.503
Median	3.500	3.370	3.450	3.710	3.500
StDev	.507	.440	.482	.597	.486
Corr. to Grad QPA	.102	-.025	-.138	.008	-.198
_r_ squared	1.0	0.1	1.9	0	3.9
_r_ squared Adj DF	0	0	0	0	0
_F_	.085	.001	.053	.001	.450
Level of Sig	No	No	No	No	No

Analysis of Variance: Age as a Determinent for Performance

```
                Mean
                Grad             Individual 95% CI for Mean
                                 Based on Pooled StDev
 Age      N     QPA    StDev     ----+---------+---------+---------+--
 20-25    19    3.272  .440      (--------*---------)
 26-30    46    3.145  .564               (-------*-------)
 31-35    23    3.569  .521                  (--------*--------)
 36 +     13    3.503  .486          (-----------*-----------)
                                 ----+---------+---------+---------+--
Performance (Grad QPA)             3.12      3.36      3.60      3.84
```

_F_=0.99: Not Significant

Summary: For off-campus ECE degree students, age does not offer significant predictive capacity nor are the variations in performance statistically accounted through student age.

TABLE #43

DEGREE AGE AND PERFORMANCE

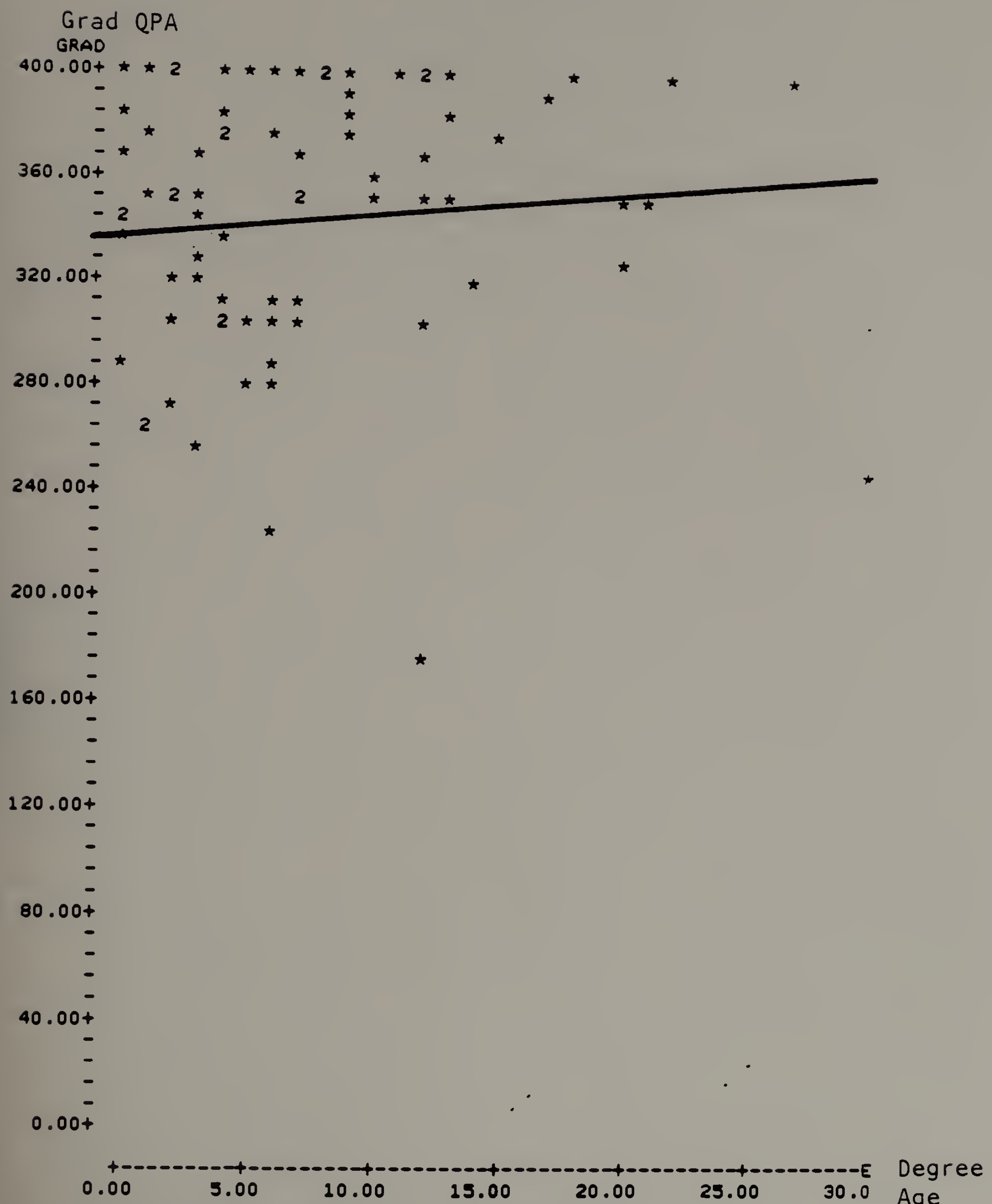
Gross Regression Analysis

Sample Size	84
Formula:	Grad = 340 + (0.800) (Deg Age)
r squared:	1.1
r squared Adjusted for DF:	0

F=.040
Not Significant

PLOT #15

DEGREE AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #2



Graduate QPA = 377 + 1.01 Degree Age
Correlation: .130
r squared: 1.7%

TABLE #43A

Description: Degree Age (Stratified)

		Grad Quality Point Ave for			
Category #2	ALL	Degree Age 0-3	Degree Age 4-5	Degree Age 6-10	Degree Age 11 +
Sample Size	84	25	11	21	20
Mean	3.441	3.388	3.415	3.485	3.543
Median	3.500	3.450	3.330	3.600	3.725
StDev	.507	.443	.452	.498	.589
Corr. to Grad QPA	.105	-.181	-.212	.507	-.094
r squared	1.1	3.3	4.5	25.7	0.9
r squared Adj DF	0	0	0	21.8	0
F	0.84	0.77	0.42	6.56	0.16
Level of Sig	No	No	No	.05	No

Analysis of Variance:
Degree Age as a Determinent for Performance

```
           Mean           Individual 95% CI for Mean
Degree     Grad           Based on Pooled StDev
 Age    N  QPA    StDev   -----+---------+---------+---------+-
 0-3   25  3.388  .443       (---------*---------)
 4-5   11  3.415  .452    (--------------*--------------)
 6-10  21  3.485  .498           (----------*----------)
 11 +  20  3.543  .589              (----------*----------)
                          -----+---------+---------+---------+-
Performance (Grad QPA)    3.20      3.40      3.60      3.80
F=0.40:  Not Significant
```

Summary: While trends exist that indicate graduate performance increasing with degree age, they are not statistically significant for off-campus ECE students. Degree age offers no predictive value for performance.

TABLE #44

GRADUATE RECORD EXAMINATION VERBAL TEST AND PERFORMANCE

Gross Regression Analysis

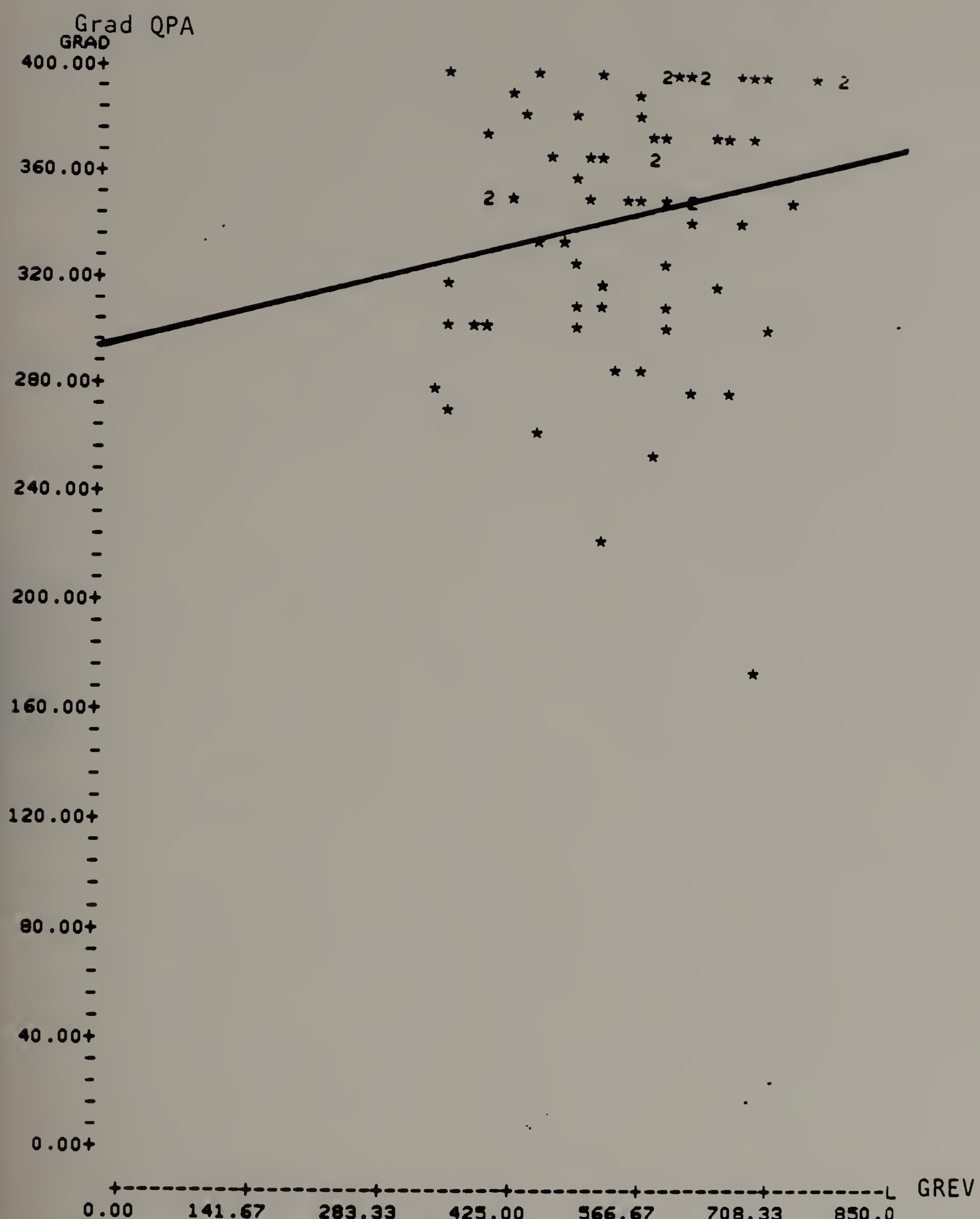
Sample Size	84
Formula:	Grad = 294 + (0.0930) (GREV)
r squared:	4.7
r squared Adjusted for DF:	3.3

F=1.02

Not Significant

PLOT #16

GRE VERBAL VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #2



Graduate QPA = 294 + 0.0930 GREV
Correlation: .217
r squared: 4.7%

TABLE #44A

Description: GRE Verbal Test (Stratified)

Category #2	ALL	Grad Quality Point Ave for GRE Verbal 0-500	GRE Verbal 501-600	GRE Verbal 601 +
Sample Size	84	23	24	23
Mean	3.441	3.374	3.425	3.570
Median	3.500	3.370	3.500	3.750
StDev	.507	.411	.467	.565
Corr. to Grad QPA	.217	.263	.105	.146
r squared	4.7	6.9	1.1	2.1
r squared Ad DF	3.3	2.5	0	0
F	3.37	1.56	0.24	0.46
Level of Sig	No	No	No	No

Analysis of Variance:
Graduate Record Examination Verbal as a Determinent for Performance

```
             Mean              Individual 95% CI for Mean
 GRE         Grad              Based on Pooled StDev
Verbal  N    QPA    StDev     --+---------+---------+---------+----
0-500   23  3.374   .411       (---------*---------)
501-6/  24  3.425   .467         (---------*---------)
601 +   23  3.570   .565                (----------*---------)
                              --+---------+---------+---------+----
Performance (Grad QPA)  3.20      3.40      3.60      3.80
F=1.02:  Not Significant
```

Summary: The GRE Verbal test is not a statistically significant predictor for performance among off-campus ECE degree students. Though a trend exists offering higher mean performance with increasing scores on the GREV, the variations are not significantly related to variations in performance.

TABLE #45

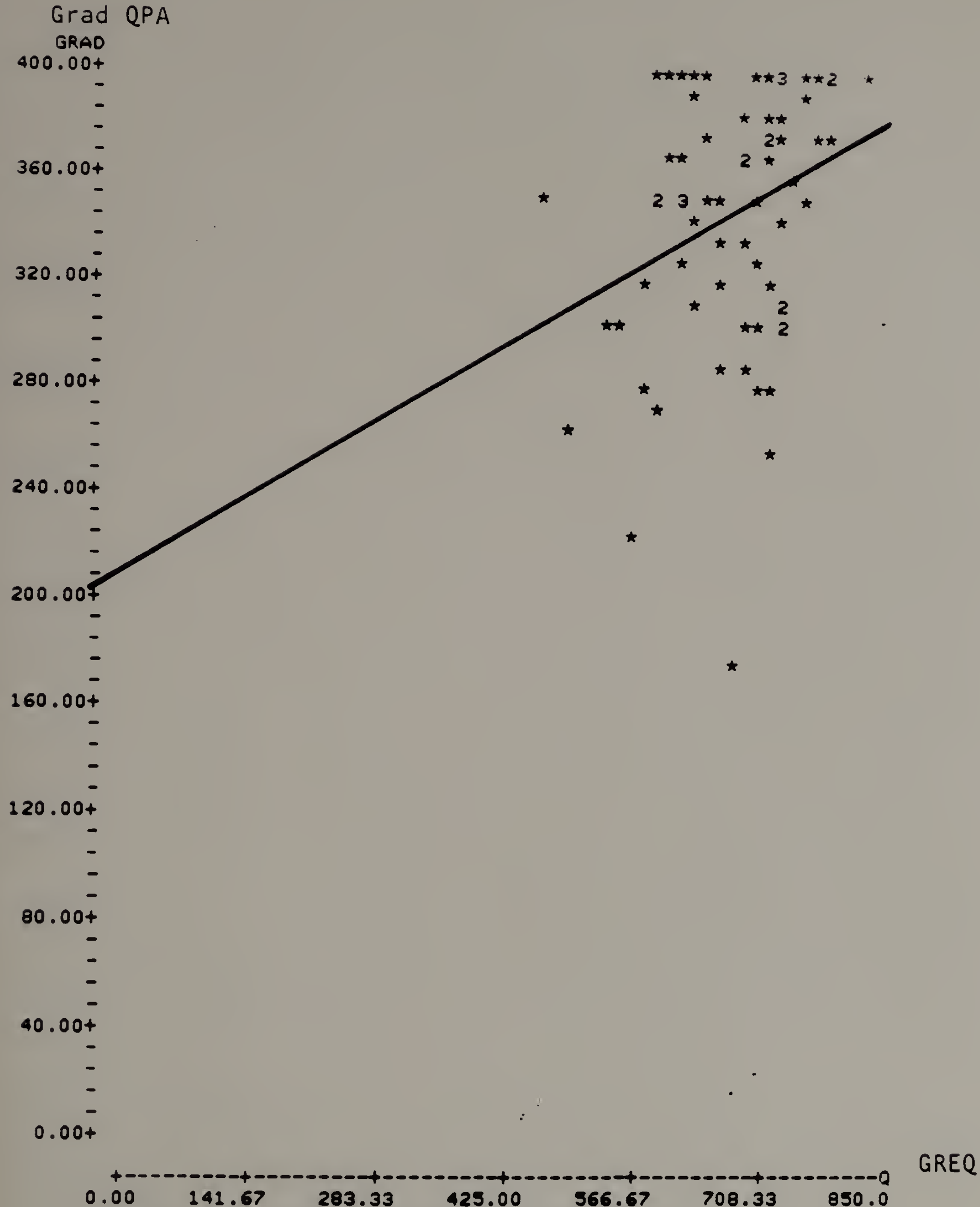
GRADUATE RECORD EXAMINATION QUANTITATIVE TEST AND PERFORMANCE

Gross Regression Analysis

Sample Size	84
Formula:	Grad = 204 + (0.208) (GREQ)
r squared:	10.0
r squared Adjusted for DF:	8.7
F=4.25	
Significant to the .05 level	

PLOT #17

GRE QUANTITATIVE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #2



Graduate QPA = 204 + 0.208 GREQ
Correlation: .316
r squared: 10.0%

TABLE #45A

Description: GRE Quantitative Test (Stratified)

Category #2	ALL	Grad Quality Point Ave for GRE Quant 0-600	GRE Quant 601-700	GRE Quant 701 +
Sample Size	84	11	26	33
Mean	3.441	3.102	3.459	3.572
Median	3.500	3.000	3.500	3.750
StDev	.507	.495	.487	.435
Corr. to Grad QPA	.316	.118	-.369	.433
r squared	10.0	1.4	13.6	18.7
r squared Ad DF	8.7	0	10.0	16.0
F	7.55	0.13	3.77	7.15
Level of Sig	.01	No	No	.05

Analysis of Variance:
Graduate Record Examination Quantitative
as a Determinent for Performance

```
               Mean            Individual 95% CI for Mean
GRE            Grad            Based on Pooled StDev
Quant   N      QPA   StDev     ------+---------+---------+---------+
0-600   11  3.102   .495      (--------*---------)
601-7/  26  3.459   .487                 (-----*-----)
701 +   33  3.572   .435                      (----*----)
                               ------+---------+---------+---------+
Performance (Grad QPA)          3.00      3.30      3.60      3.90
F=4.22:  Significant at the .05 Level
```

Note: No significant performance differences exist between students with GREQ scores ranging from 0-600 and 601-700 or between students scoring 601-700 and 701 and above. However, significant differences (.05 level) do exist between students scoring from 0-600 and 701 and above.

Summary: For off-campus ECE degree students, results on the GREQ offer significant predictive capability. The trend indicates better performance with higher GREQ scores and this is supported by the ANOVA showing statistically significant differences exiting between variations on GREQ scores and graduate performance. Statistically significant differences in performance exist between those students scoring below 601 on the GREQ and those scoring above 701.

TABLE #46

GRADUATE RECORD EXAMINATION ANALYTIC TEST AND PERFORMANCE

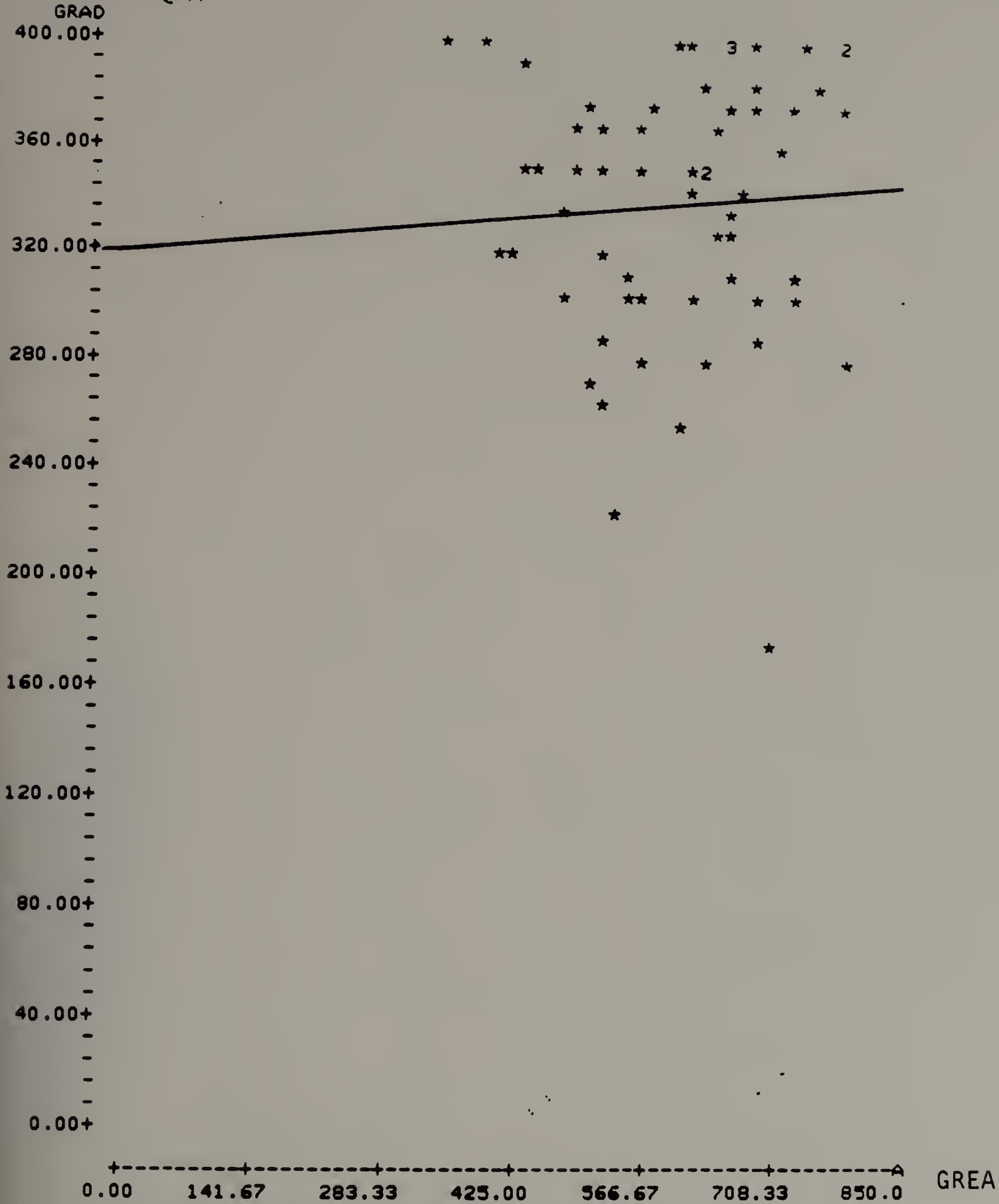
Gross Regression Analysis

Sample Size	84
Formula:	Grad = 320 + (0.0340) (GREA)
r squared:	0.6
r squared Adjusted for DF:	0
F=1.77	
Not Significant	

PLOT #18

GRE ANALYTIC VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #2

Grad QPA



Graduate QPA = 320 + 0.0340 GREA
Correlation: .076
r squared: 0.6%

TABLE #46A

Description: GRE Analytic Test (Stratified)

Category #2	ALL	Grad Quality Point Ave for GRE Analy 0-500	GRE Analy 510-600	GRE Analy 601-700	GRE Analy 701 +
Sample Size	84	11	15	25	11
Mean	3.441	3.520	3.167	3.501	3.415
Median	3.500	3.500	3.120	3.500	3.750
StDev	.507	.346	.463	.426	.698
Corr. to Grad QPA	.076	-.439	.113	.120	.459
_r_ squared	0.6	19.2	1.3	1.4	21.0
_r_ squared Ad DF	0	10.3	0	0	12.3
_F_	0.35	2.14	0.17	0.34	2.40
Level of Sig	No	No	No	No	No

Analysis of Variance:
Graduate Record Examination Analytic
as a Determinent for Performance

```
                Mean
 GRE            Grad              Individual 95% CI for Mean
                                  Based on Pooled StDev
Analy   N   QPA    StDev   ---+---------+---------+---------+---
0-500   11  3.520  .346            (--------*---------)
501-6/  15  3.167  .463    (--------*-------)
601-7/  25  3.501  .426                (------*-----)
701 +   11  3.415  .698          (---------*---------)
                           ---+---------+---------+---------+---
Performance (Grad QPA) 3.00      3.30      3.60      3.90
F=1.77:  No Significant
```

Summary: The GRE Analytic test offers no relationship to variances in performance experienced by off-campus ECE degree students.

TABLE #47

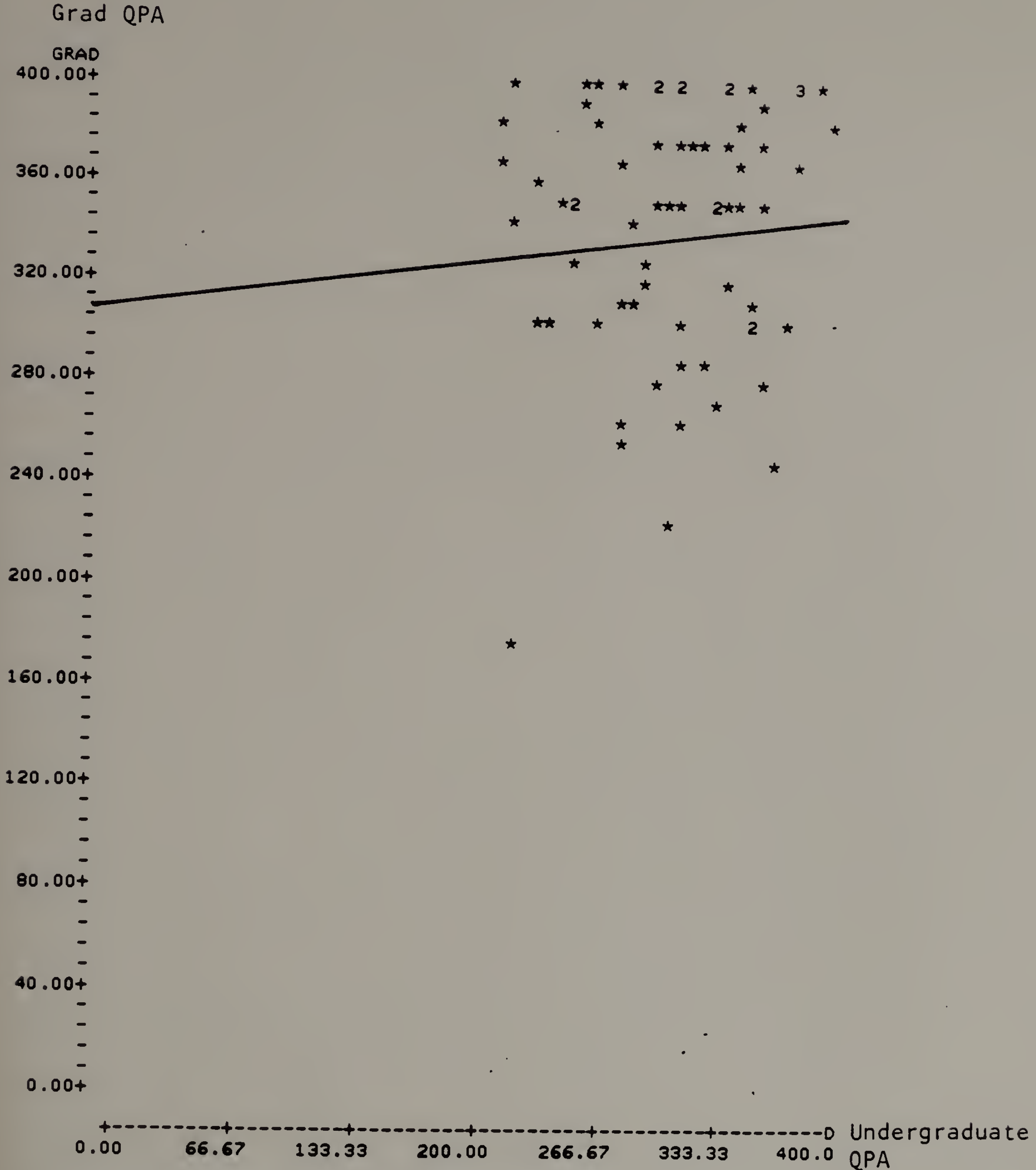
UNDERGRADUATE QUALITY POINT AVERAGE AND PERFORMANCE

Gross Regression Analysis

Sample Size	84
Formula:	Grad = 298 + (0.151) (UGRAD)
_r_ squared:	2.1
_r_ squared Adjusted for DF:	0.6
_F_=0.62	
_N_ot Significant	

PLOT #19

UNDERGRADUATE QPA VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #2



Graduate QPA = 298 + .151 Undergraduate QPA
Correlation: .144
r squared: 2.1%

TABLE #47A

Description: GRE Analytic Test (Stratified)

Category #2	ALL	Grad Quality Point Ave for Ugrad QPA 0-3.00	Ugrad QPA 3.01-3.50	Ugrad QPA 3.51-4.00
Sample Size	84	27	29	14
Mean	3.441	3.383	3.439	3.569
Median	3.500	3.500	3.500	3.780
StDev	.507	.517	.493	.522
Corr. to Grad QPA	.144	-.010	.076	.367
r squared	2.1	0	0.6	13.5
r squared Ad DF	0.6	0	0	6.3
F	1.44	0.00	0.16	1.87
Level of Sig	No	No	No	No

Analysis of Variance:
Undergraduate QceWKQg =rKoQ ?unwevn
as a Determinent for Performance

```
             Mean         Individual 95% CI for Mean
Ugrad        Grad         Based on Pooled StDev
 QPA       N QPA     StDev-+---------+---------+---------+-----
0-3.00    27 3.383   .517(----------*----------)
3.01/50   29 3.439   .493    (---------*---------)
3.51/400  14 3.569   .522      (-------------*-------------)
                         -+---------+---------+---------+-----
Performance (Grad QPA) 3.20      3.40      3.60      3.80
F=0.62:  Not Significant
```

Summary: Though trends indicate higher undergraduate quality point average resulting in higher graduate performance for off-campus ECE degree students, the undergraduate record is not a significant predictor of performance and its variations do not statistically relate to differences in graduate quality point average.

OFF-CAMPUS VIDEO-BASED NON-DEGREE GRADUATE STUDENTS
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ANALYSIS OF VARIABLES

CATEGORY #3

OFF-CAMPUS VIDEO-BASED NON-DEGREE STUDENTS DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Off-campus non-degree students enrolled in Electrical and Computer Engineering courses offered through the Videotape Instructional Program, exhibit a mean age of thirty, the same for off-campus degree students. While mean graduate quality point averages for on and off-campus degree students are 3.25 and 3.44, non-degree students performed at a relatively low mean level, 3.21. Note that this is offered recognizing that the sample is solely constituted by those students who completed VIP courses. It purposely excludes those who withdrew from courses. Were students who withdrew considered to have failed, the differences would have been much greater.

Recall that the only data available from the University's Graduate School was the individual's date of birth. This severely limited the scope of the analysis. Regardless, regression and analyses of variance were performed. Following upon the pattern established in the previous two student categories, age proved to be significant neither as a performance predictor nor could differences in student age account for variation in graduate quality grade point average.

TABLE #48

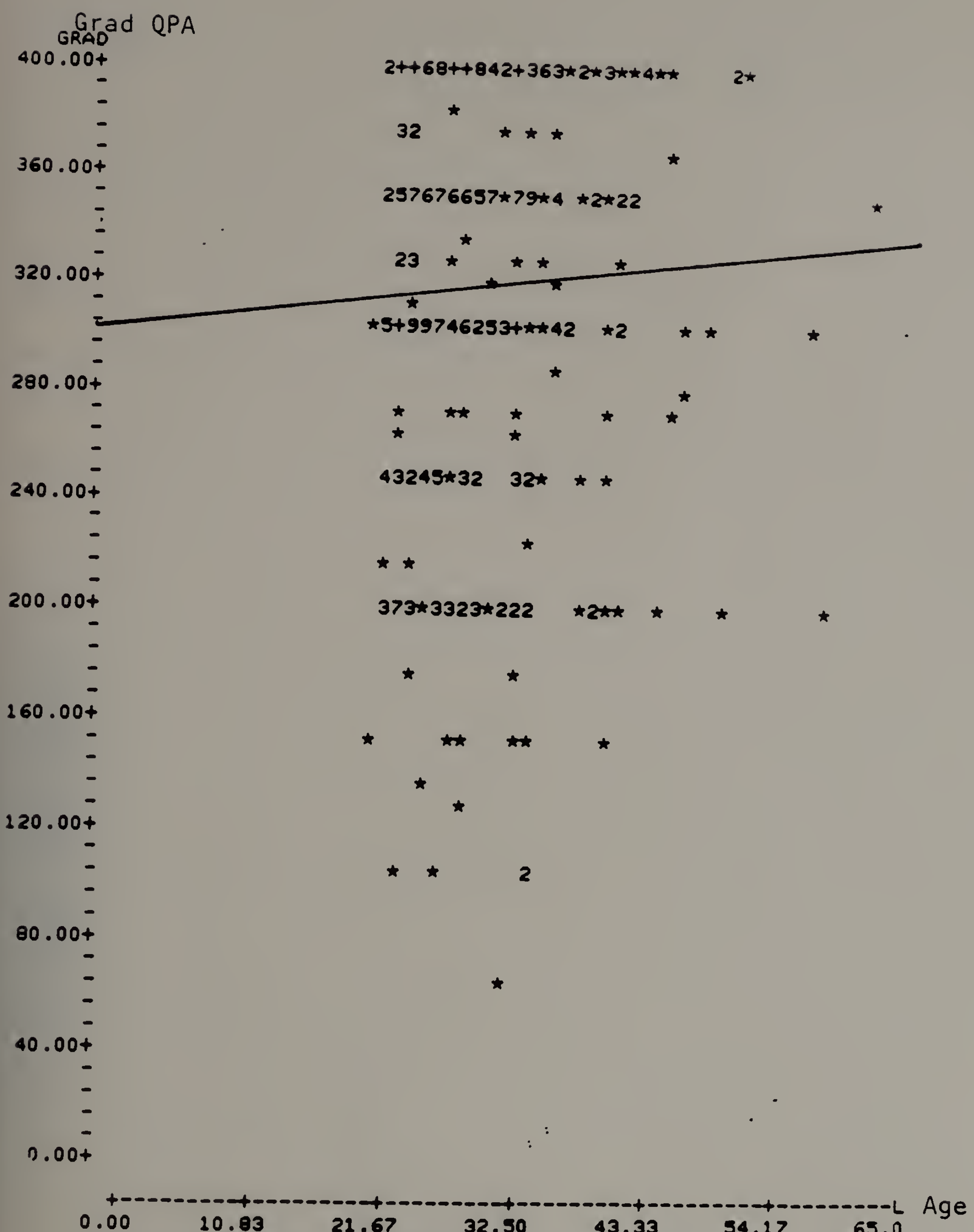
AGE AND PERFORMANCE

Gross Regression Analysis

Sample Size	418
Formula:	Grad = 303 + (0.599) (Age)
r squared:	0.3
r squared Adjusted for DF:	0
F=0.77	
Not Significant	

PLOT #20

AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #3



Graduate QPA = 303 + .599 Age
Correlation: .054
r squared: 0.3%

TABLE #48A

Description: Age (Stratified)

Category #3	ALL	Grad Quality Point Ave for Age 20-25	Age 26-30	Age 31-35	Age 36 +
Sample Size	424	140	130	83	65
Mean	3.209	3.149	3.264	3.181	3.277
Median	3.500	3.000	3.500	3.500	3.500
StDev	.744	.707	.726	.826	.699
Corr. to Grad QPA	.054	.184	.095	.136	-.052
r squared	0.3	3.4	0.9	1.9	0.3
r squared Adj DF	0.1	2.7	0.1	0.6	0
F	1.21	4.82	1.17	1.53	0.17
Level of Sig	No	.05	No	No	No

Analysis of Variance: Age as a Determinent for Performance

```
              Mean
              Grad            Individual 95% CI for Mean
                              Based on Pooled StDev
 Age     N    QPA    StDev    ---------+---------+---------+-------
20-25  140  3.149    .707      (---------*----------)
26-30  130  3.264    .726               (----------*----------)
31-35   83  3.181    .826      (------------*------------)
36 +    65  3.277    .699            (---------------*-------------
                              ---------+---------+---------+-------
Performance (Grad QPA)              3.12      3.24      3.36
F=0.99:   Not Significant
```

Summary: No relationship exists between age and performance among off-campus non-degree ECE students.

ON-CAMPUS GRADUATE DEGREE STUDENTS
DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH
ANALYSIS OF VARIABLES

CATEGORY #4

ON-CAMPUS DEGREE STUDENTS DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

On-campus graduate students in the College of Engineering's Department of Industrial Engineering/ Operations Research were slightly older than their peers in Electrical and Computer Engineering. IEOR students had a mean age of 26 compared to 25 among Electrical and Computer Engineering graduate students. Their degree age was one year older. Resident IEOR graduate students had mean test GRE scores of 468 (verbal), 627 (quantitative) and 545 (analytic). Their mean undergraduate and graduate quality point averages were was 3.06 and 3.35, both on a four-point scale.

Correlations between the variables and graduate performance were higher among these students than of any others in the study. For instance, the correlation of the GRE analytic test to performance is twice as high for students in the group than for on-campus students in Electrical and Computer Engineering.

Age and degree age correlated -.338 and -.307 respectively, both significant to the .01 level. The similarity of these two correlations is expected as they correlate .909, one to another. Correlations to performance of age and degree age are the highest among all of the variables considered for on-campus IEOR students.

To this point, data have consistently indicated positive correlations of age to performance. This category of student offers the first instance when this is not the case. Indeed there is a significantly negative correlation. When regressed against performance, age was found to be a strong predictor (.01 level) for 11.4% of the population (10.4% when corrected for degrees of freedom). While the r squared is low, its level of significance and the fact that this is the first instance where age is found to negatively correlate with performance is considered consequential.

The analysis of variances of age against performance was also significant and noted that as age increases from a 20-25 to 26-30, and from 31 and above, performance decreases 3.45, 3.39, and 2.72.

This ANOVA was significant to the .01 level while the Scheffe conducted on the latter two ages groups also showed significant differences at the .05 level.

Particular attention should be paid to the chart noting the correlations for stratified ages against performance. While the correlations for none of the three groups are statistically significant, they may offer helpful hints if considered in light of the IEOR curricula. While quantitatively oriented, the Industrial Engineering program also benefits from a wide range of real world industrial applications. Reason would allow that the more successful students would combine work experience with strong quantitative abilities. If this is a valid assumption, then students with an age range from 26 to 30 (.313 correlation to performance, mean graduate quality point average of 3.38) offer the strongest combination of work experience and a sufficiently fresh undergraduate experience to allow quantitative competency. On the other hand, older students, with ages beyond thirty (mean quality point average of 2.73), while strong in industrial experience and dedication to the educational process, may have mathematical competencies that are either obsolete or too stale to allow mastering the required quantitative aspects of the program.

This assumption is further supported by data associated with degree age and its relationship to performance. In the three strata of degree age, 0 to 1, 2 to 3, and 4 and above, students in the first category had a mean graduate quality point average of 3.36. Students in the second group had a mean average of 3.51 while students in the third recorded a mean of 3.16. Again we might assume that students in the second category combined optimally fresh quantitative skills with practical work experience. Performance by students in the third and oldest group indicated that their substantial work experiences could not compensate for stale quantitative abilities. Note that in this last and oldest category, the predictive value, although insignificant, was 13.8% (8.7% adjusted for degrees of freedom).

These statements are offered with the caveat that none of the above are proven statistically significant, including the ANOVA establishing statistical relationship between degree age and graduate performance.

The analyses of variance seeking to determine the relationship of performance to the GRE proved inconclusive and insignificant for the scores on the analytic and verbal tests. The predictive power for the analytic test proved to be 0% when corrected for degrees of freedom and 5.2% for the verbal (3.8% when adjusted).

Though scores on the Verbal test proved generally insignificant, curious note is taken of the fact that students scoring above 600 exhibited a -.816 correlation when test scores were related to grades. When this factor was regressed, the predictive power was an astounding 66.5% (61.8% when corrected for degrees of freedom). This statistic proved significant to the .01 level. Note that in all levels except when students scored above 600, the graduate quality point average rose as did the score of the verbal test. Were the sample of size of students scoring above 600 on the GREV larger than nine, more credence could be attached to the statistic. However, its correlations and levels of significance indicate that a relationship does exist. It is clearly one that would benefit from future study.

TABLE #49

MEAN GRADUATE QPA AND GRE VERBAL TEST SCORE
ON-CAMPUS IEOR GRADUATE STUDENTS

GRE Verbal Test Score	Mean Graduate Quality Point Average
200-400	3.20
401-500	3.26
501-600	3.59
601 +	3.19

The GRE Verbal statistic also indicated the existence of a base-level for graduate performance among students in this category. Students scoring from 200 to 500 had mean graduate performance ranging from 3.20 to 3.26. However, students in the range from 501 to 600 had a mean graduate quality point average of 3.59. Again, all data are insignificant with the exception of the regression analysis for students with GRE verbal tests with scores higher than 600 and even in this case, the sample size was marginal.

Just as with the Verbal GRE, students scoring higher than 600 on the analytic portion of the examination also exhibited a negative correlation to performance, -.301. The regression analysis, though not significant, offered predictive power for 9.0% of the population (only 5.1% when corrected for degrees of freedom). While both low and insignificant, attention should be paid to this trend, especially given the unexceptional correlation of .585 between the verbal and analytic tests.

The overall relationship of performance on the GRE quantitative test to graduate grades is .366 and significant to the .01 level and a strong correlation exists for those 10 on-campus IEOR students with scores in excess of 700. Albeit insignificant, the regression analysis showed predictive capacity for 20.4% of the students sampled (10.4% when adjusted) The ANOVA seeking to determine if changes in the GRE quantitative score effected performance proved significant to the .01 level. Post-hoc testing offered inconsequential differences between groups.

The correlation of undergraduate to graduate performance was .246 and was significant to the .01 level. The regression model, which proved not to be significant, offered an overall predictive value of 6.1% (4.8% when adjusted for degrees of freedom).

An analysis of variance measuring the impact of differing undergraduate grades on graduate performance proved statistically insignificant. Note is taken of the fact that the correlation of undergraduate grades in the range of 3.51 to 4.00 to graduate performance was only .230. This offers further support for the argument that undergraduate performance, when viewed out of the contexts of the age and degree age, are diminished in importance. Again, in this program, a combination of real-world experience and a still fresh working ability in mathematics and statistics seem required for success.

This balancing effect seems borne out with the results of the step-wise regression analysis. When all of the variables are regressed in this fashion, the two that stand-out are students' chronological age and scores on the GRE quantitative test. Combined, they predict performance for 21.8% of the population!

The preceeding were based on the following data.

ON-CAMPUS GRADUATE STUDENTS
DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

TABLE #50

SUMMARY DESCRIPTION

Category #4	Age	Degree Age	Graduate Verbal	Record Quant	Exam Analy	Ugrad QPA	Grad QPA
Sample Size	85	85	81	81	74	79	83
Mean	26.19	3.28	468.0	626.7	545.0	3.061	3.347
Median	25.00	2.00	490.0	640.0	565.0	3.070	3.450
StDev	5.48	5.47	128.0	84.6	124.0	.381	.603

INTERACTIVE CORRELATIONS

Category #4	Age	Degree Age	Graduate Verbal	Record Quant	Exam Analy	Ugrad QPA
Degree Age	.909					
GRE Verb	.194	.187				
GRE Quant	-.106	-.080	.274			
GRE Anal	-.096	-.079	.585	.526		
Ugrad QPA	-.268	-.274	.174	.282	.194	
Grad QPA	-.338	-.307	.057	.366	.228	.246

TABLE #51

AGE AND PERFORMANCE

Gross Regression Analysis

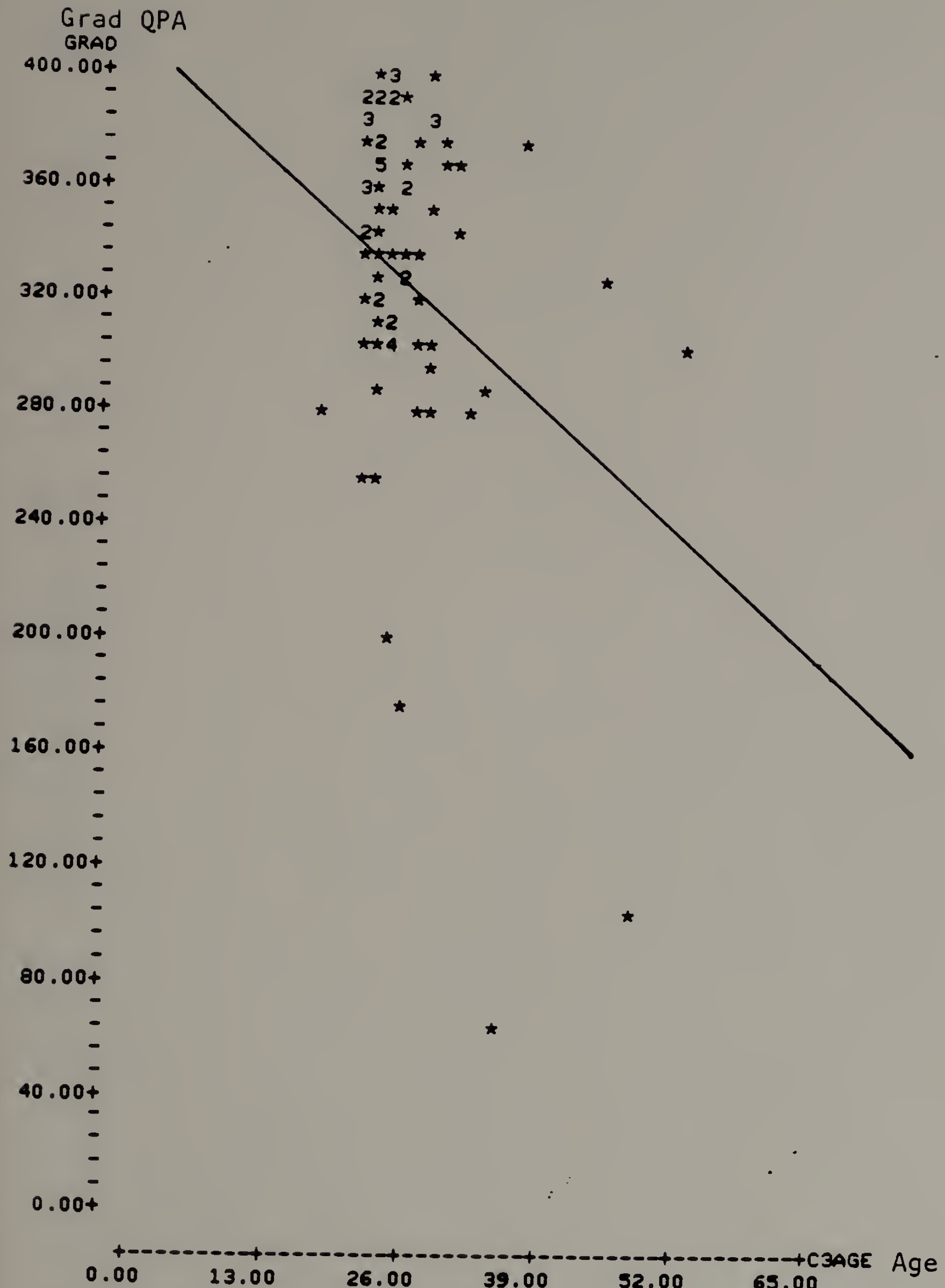
Sample Size	83
Formula:	Grad = 431 - (3.67) (Age)
r squared:	11.4
r squared Adjusted for DF:	10.4

F=6.27

Significant to the .01 level

PLOT #21

AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #4



Graduate QPA = 431 - 3.67 Age
Correlation: -.338
r squared: 11.4%

TABLE #51A

Description: Age (Stratified)

Category #4	Grad Quality Point Ave for ALL	Age 20-25	Age 26-30	Age 31 +
Sample Size	83	50	23	9
Mean	3.347	3.453	3.381	2.730
Median	3.450	3.555	3.500	3.070
StDev	.603	.439	.511	.114
Corr. to Grad QPA	-.338	-.165	.313	-.196
_r_ squared	11.4	2.7	9.8	3.8
_r_ squared Adj DF	10.3	0.7	5.5	0
_F_	10.42	1.35	2.28	0.28
Level of Sig	.01	No	No	No

Analysis of Variance: Age as a Determinent for Performance

```
             Mean           Individual 95% CI for Mean
             Grad           Based on Pooled StDev
 Age    N    QPA   StDev   --+---------+---------+---------+----
20-25   50 3.453   .439                              (---*---)
26-30   23 3.381   .511                          (-----*----)
31 +     9 2.727  1.138     (--------*---------)
                           --+---------+---------+---------+----
Performance (Grad QPA)  2.40      2.80      3.20      3.60
```

_F_=6.27: Significant at the .01 Level

Note: significant differences to the .05 level exist for performance among students in with ages ranges from 26-30 as compared to students in category #4 with ages higher than thirty.

Summary: Age offers significant predictive capability for on-campus IEOR graduate students. There is a significant relationship between variation in student age and graduate performance. Significant differences in performance are noted between students with ages ranging from 26 to 30 versus those above 30.

TABLE #52

DEGREE AGE AND PERFORMANCE

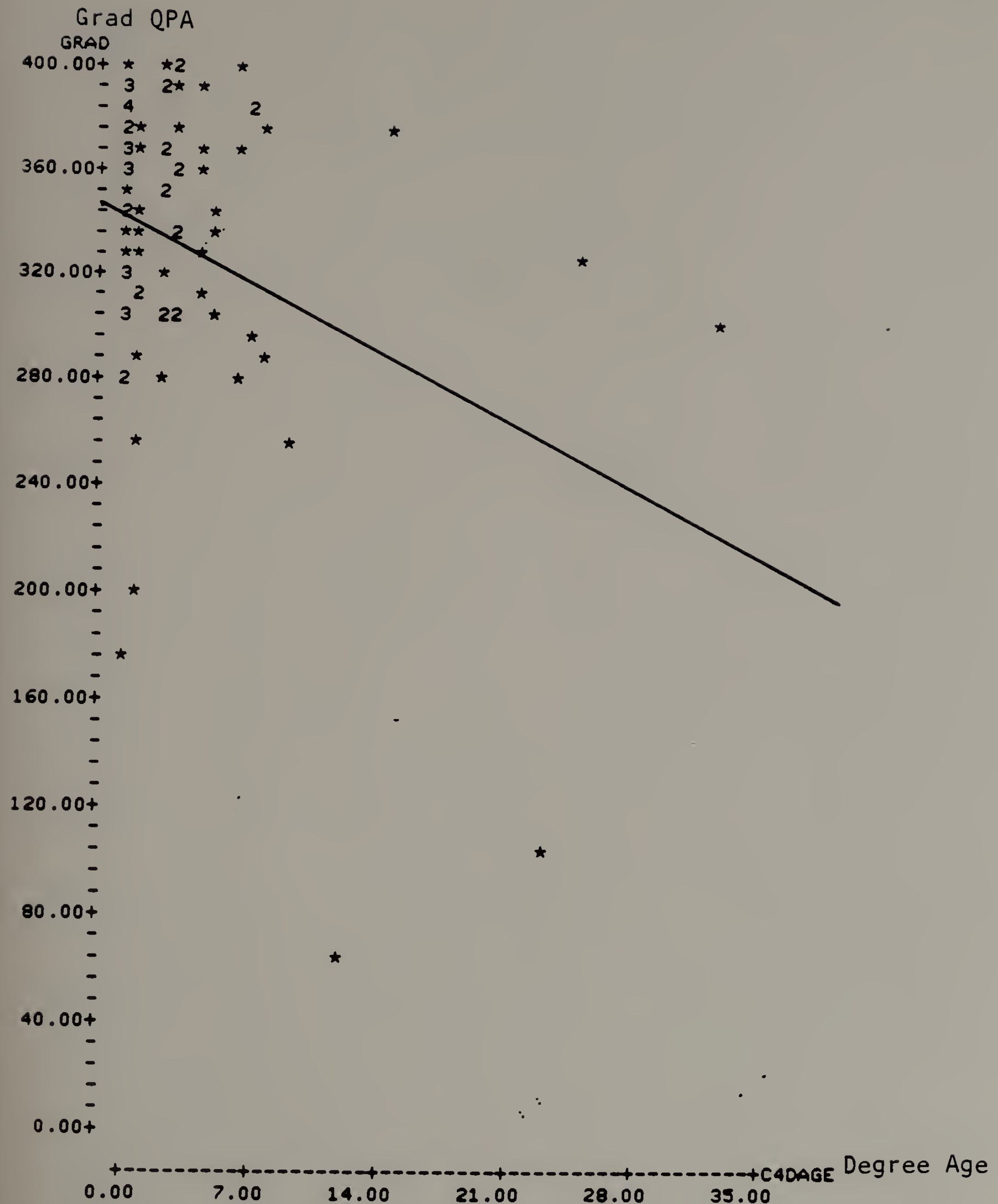
Gross Regression Analysis

Sample Size	83
Formula:	Grad = 346 - (3.35) (Deg Age)
r squared:	9.4
r squared Adjusted for DF:	8.3

F=1.95
Not Significant

PLOT #22

DEGREE AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #4



Graduate QPA = 346 - 3.35 Degree Age
Correlation: -.307
r squared: 9.4%

TABLE #52A

Description: Degree Age (Stratified)

Category #4	ALL	Grad Quality Point Ave for Degree Age 0-1	Degree Age 2-3	Degree Age 4 +
Sample Size	83	40	21	22
Mean	3.347	3.365	3.512	3.156
Median	3.450	3.445	3.600	3.310
StDev	.603	.502	.389	.862
Corr. to Grad QPA	-.307	-.301	.120	-.361
r squared	9.4	9.0	1.4	13.8
r squared Adj DF	8.3	6.6	0	8.7
F	8.42	3.77	0.28	2.99
Level of Sig	.01	No	No	No

Analysis of Variance:
Degree Age as a Determinent for Performance

```
                Mean
Degree          Grad            Individual 95% CI for Mean
 Age     N      QPA    StDev    Based on Pooled StDev
                                ----------+---------+---------+------
 0-1    40    3.365    .502                (-------*-------)
 2-3    21    3.512    .389                     (---------*----------
 4 +    22    3.156    .862       (----------+---------)
                                ----------+---------+---------+------
Performance (Grad QPA)                  3.12      3.36      3.60
F=1.95:  Not Significant
```

Summary: Although a trend exists indicating that IEOR on campus students with degree ages ranging from 2-3 perform at a higher level than students in the other degree age categories, degree age proves not to be a statistically significant predictor of performance. Variations in degree age do not significantly account for variations in graduate performance.

TABLE #53

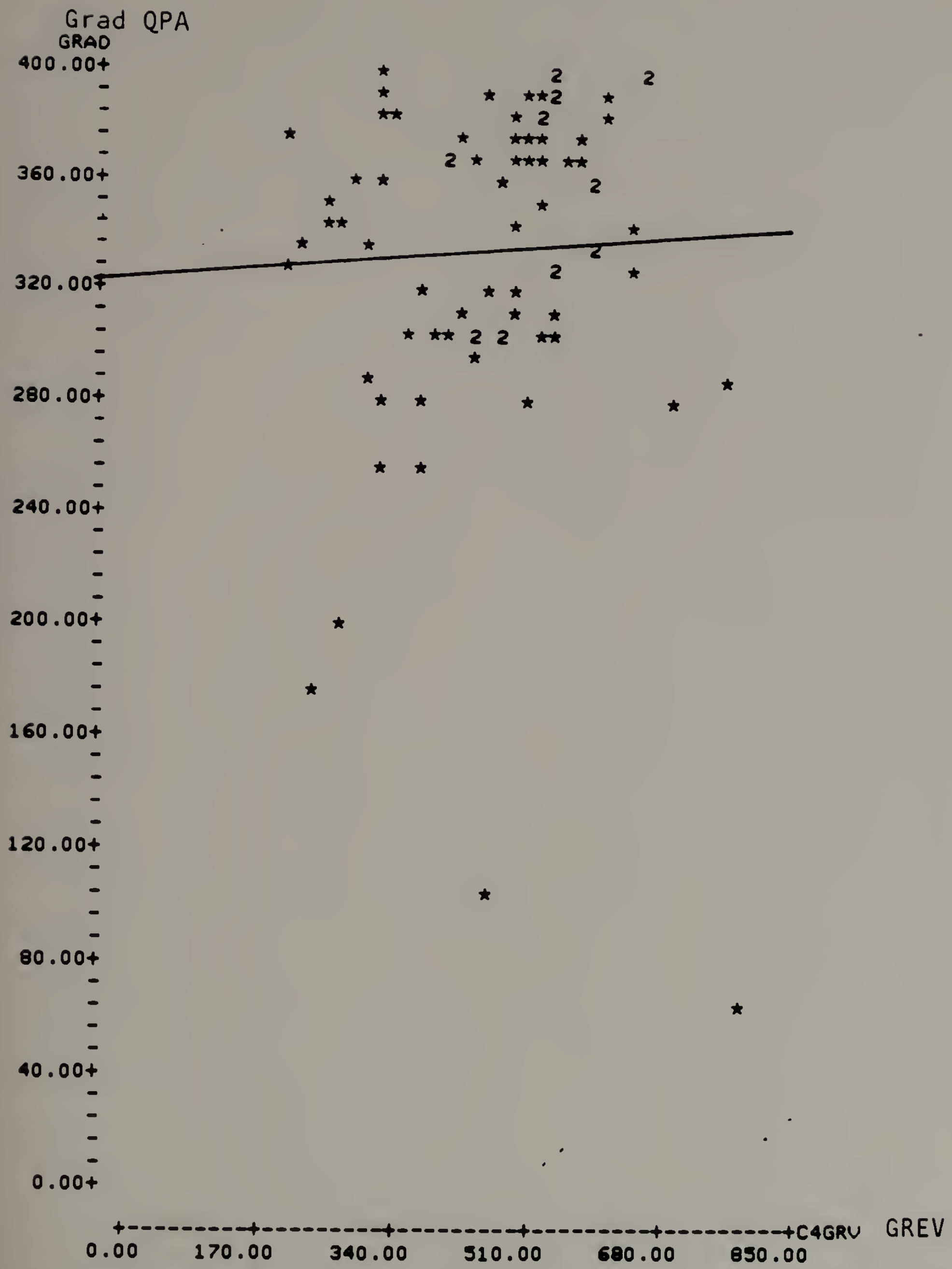
GRADUATE RECORD EXAMINATION VERBAL TEST AND PERFORMANCE

Gross Regression Analysis

Sample Size	83
Formula:	Grad = 322 + (0.0274) (GREV)
r squared:	0.3
r squared Adjusted for DF:	0
F=2.19	
Not Significant	

PLOT #23

GRE VERBAL VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #4



Graduate QPA = 322 + 0.0274 GREV
Correlation: .057
r squared: 0.3%

TABLE #53A

Description: GRE Verbal Test (Stratified)

Category #4	ALL	Grad Quality Point Ave for GRE Verbal 200-400	GRE Verbal 401-500	GRE Verbal 501-600	GRE Verbal 601 +
Sample Size	83	25	19	26	9
Mean	3.347	3.203	3.262	3.590	3.190
Median	3.450	3.330	3.200	3.660	3.450
StDev	.603	.571	.652	.333	.107
Corr. to Grad QPA	.057	.006	.033	-.056	-.816
r squared	0.3	0	0.1	0.3	66.5
r squared Ad DF	0	0	0	0	61.8
F	0.25	0.00	0.02	0.59	13.92
Level of Sig	No	No	No	No	.01

Analysis of Variance:
Graduate Record Examination Verbal as a Determinent for Performance

```
                  Mean
 GRE              Grad              Individual 95% CI for Mean
 Verbal  N        QPA      StDev    Based on Pooled StDev
                                    -------+---------+---------+---------
 200-4/  25       3.202    .571        (-------*-------)
 401-5/  19       3.262    .652         (--------*--------)
 501-6/  26       3.590    .333                     (-------*-------)
 601 +    9       3.194    1.065    (-------------*-------------)
                                    -------+---------+---------+---------
 Performance (Grad QPA)                 3.00      3.30      3.60
 F=2.19:  Not Significant
```

Summary: The GRE Verbal is not a statistically significant predictor of performance for on-campus IEOR graduate students. Variations in GREV scores are not statistically related to variation in graduate performance.

TABLE #54

GRADUATE RECORD EXAMINATION QUANTITATIVE TEST AND PERFORMANCE

Gross Regression Analysis

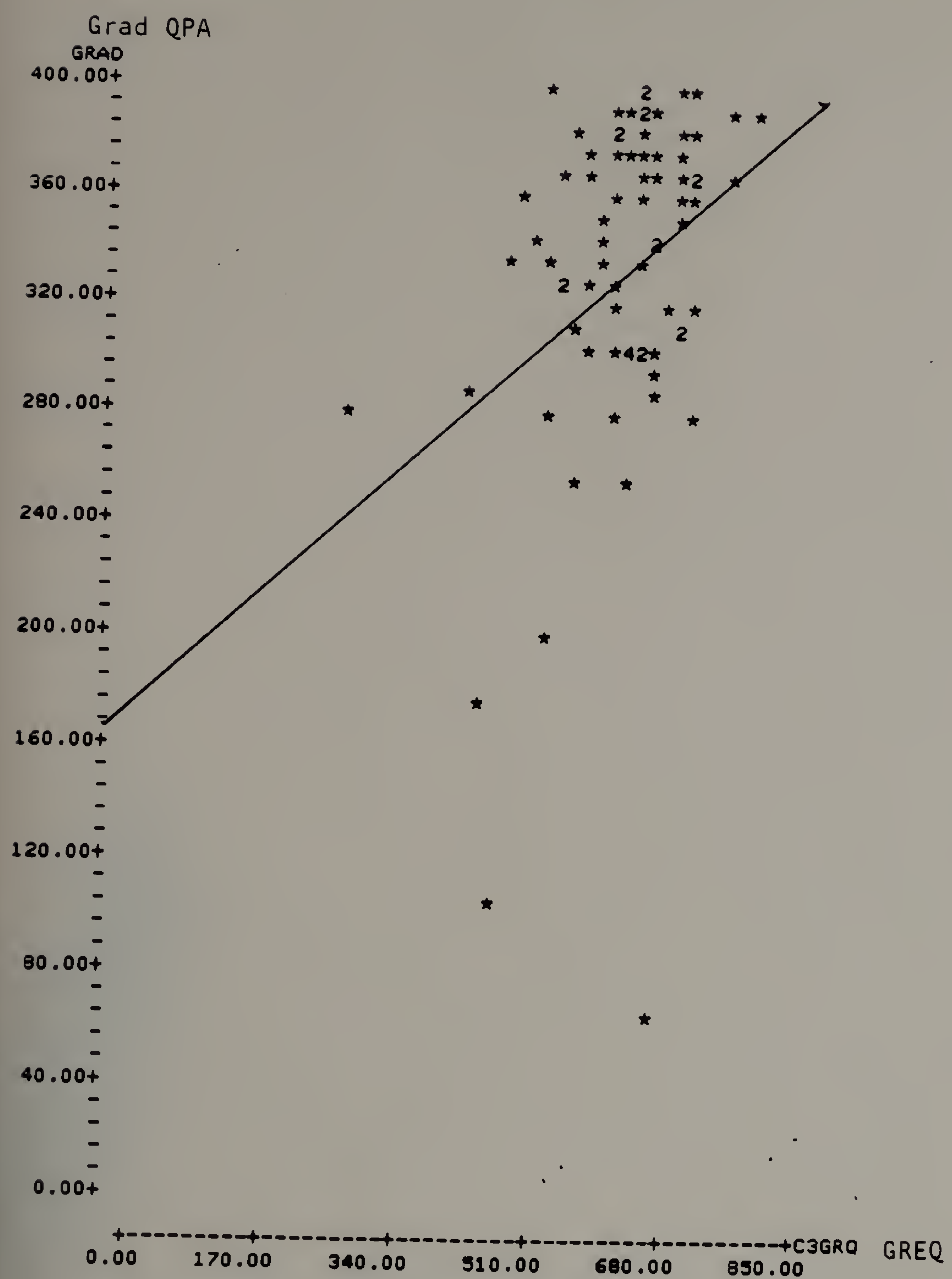
Sample Size	83
Formula:	Grad = 166 + (0.269) (GREQ)
r squared:	13.4
r squared Adjusted for DF:	12.3

F=4.53

Significant to the .01 level

PLOT #24

GRE QUANTITATIVE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #4



Graduate QPA = 166 + 0.269 GREQ
Correlation: .366
r squared: 13.4%

TABLE #54A

Description: GRE Quantitative Test (Stratified)

		Grad Quality Point Ave for			
Category #4	ALL	GRE Quant 200-500	GRE Quant 501-600	GRE Quant 601-700	GRE Quant 701 +
Sample Size	83	6	18	84	10
Mean	3.347	2.570	3.294	3.404	3.624
Median	3.450	2.850	3.345	3.600	3.680
StDev	.603	1.00	.481	.583	.369
Corr. to Grad QPA	.366	-.005	.214	.069	.452
_r_ squared	13.4	0	4.6	0.5	20.4
_r_ squared Ad DF	12.3	0	0	0	10.4
_F_	11.94	0.00	0.77	0.20	2.05
Level of Sig	.01	No	No	No	No

Analysis of Variance:
Graduate Record Examination Quantitative
as a Determinent for Performance

```
                          Individual 95% CI for Mean
GRE        Mean           Based on Pooled StDev
Quant  N   Grad QPA StDev ----+---------+---------+---------+-
200-5/  6  2.573  1.004  (-------*-------)
501-6/ 18  3.294   .481             (----*---)
601-7/ 45  3.404   .583                 (--*--)
701 +  10  3.624   .369                 (-----*-----)
                         ----+---------+---------+---------+-
Performance (Grad QPA)     2.40      3.00      3.60      4.20
```

_F_=4.53: Significant at the .01 level

Note: Post-hoc analyses note no significant differences in performance between students scoring 200-500 and 501-600, 501-600 and 601-700, and 601-700 and 701 and above. However, statistically significant variations were found between students with GREQ scores from 200 and 500 versus those with scores above 700.

Summary: The GRE Quantitative test is a statistically significant predictor of performance among on-campus IEOR graduate students. Variations in the GREQ are significantly to variations in performance with a statistically significant difference in performance for students scoring 200-500 on the GREQ and those scoring above 700.

TABLE #55

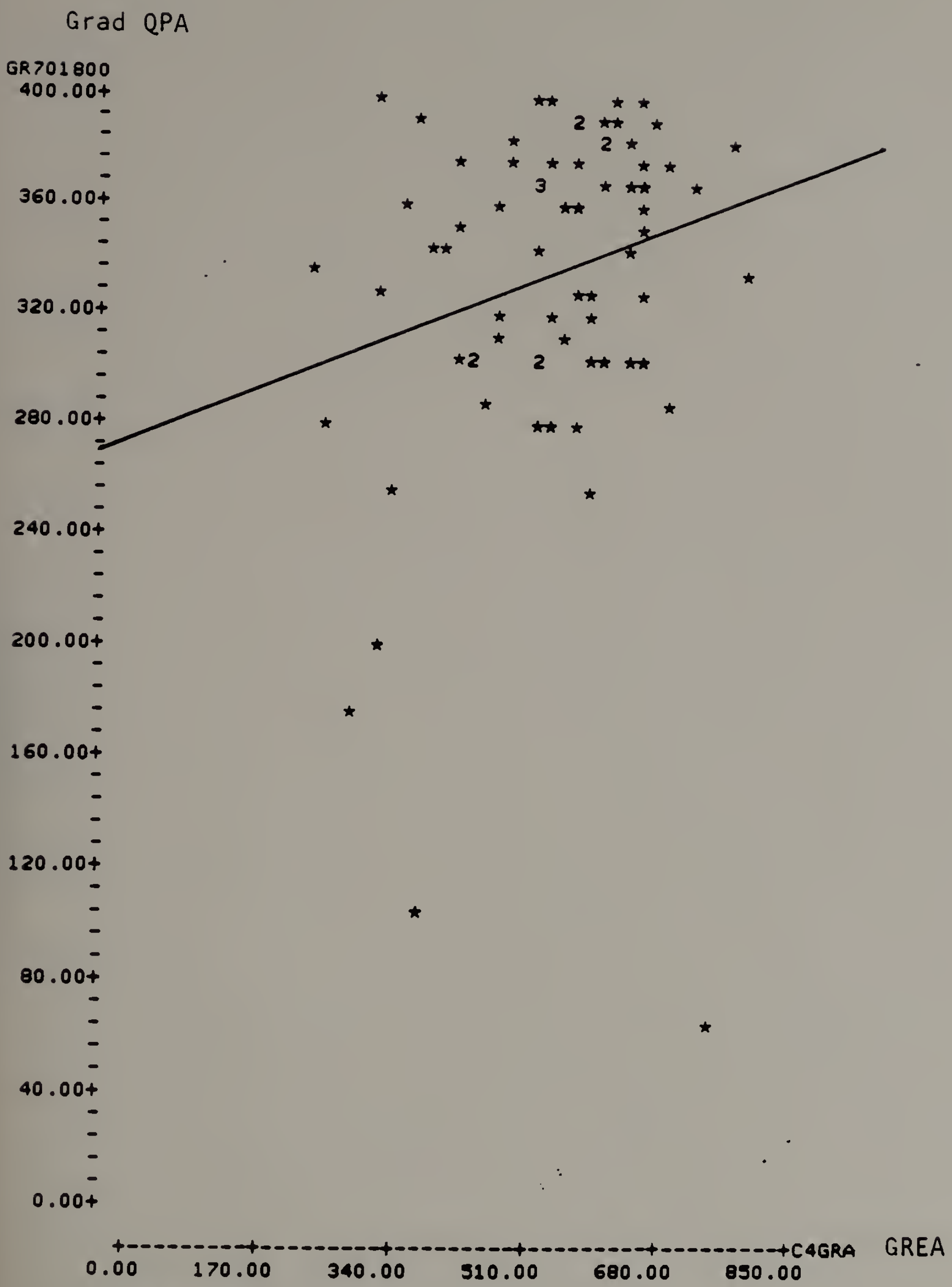
GRADUATE RECORD EXAMINATION ANALYTIC TEST AND PERFORMANCE

Gross Regression Analysis

Sample Size	83
Formula:	Grad = 270 + (0.116) (GREA)
_r_ squared:	5.2
_r_ squared Adjusted for DF:	3.8
_F_=2.05	
Not Significant	

PLOT #25

GRE ANALYTIC VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #4



Graduate QPA = 270 + .116 GREA
Correlation: .228
r squared: 5.2%

TABLE #55A

Description: GRE Analytic Test (Stratified)

Category #4	ALL	Grad Quality Point Ave for GRE Analy 0-500	GRE Analy 501-600	GRE Analy 601 +
Sample Size	83	23	24	25
Mean	3.347	3.122	3.380	3.480
Median	3.450	3.250	3.355	3.700
StDev	.603	.727	.432	.685
Corr. to Grad QPA	.228	.319	-.182	-.301
_r_ squared	5.2	10.2	3.3	9.0
_r_ squared Ad DF	3.8	5.9	0	5.1
_F_	3.84	2.37	0.75	2.28
Level of Sig	No	No	No	No

Analysis of Variance:
Graduate Record Examination Analytic
as a Determinent for Performance

```
                Mean
 GRE            Grad             Individual 95% CI for Mean
                                 Based on Pooled StDev
Analy   N   QPA     StDev    -+---------+---------+---------+-----
0-500   23  3.122   .727     (----------*----------)
501-6/  24  3.380   .432               (----------*---------)
601 +   25  3.480   .685                    (---------*---------)
                             -+---------+---------+---------+-----
Performance (Grad QPA)  2.88      3.12      3.36      3.60
F=2.05:  Not Significant
```

Summary: The GRE Analytic test is not a significant predictor for performance of IEOR on-campus graduate students. Though a trend exists that indicates higher performance with higher GREA test scores, variations in the GREA are not statistically significant in accounting for variations in performance.

TABLE #56

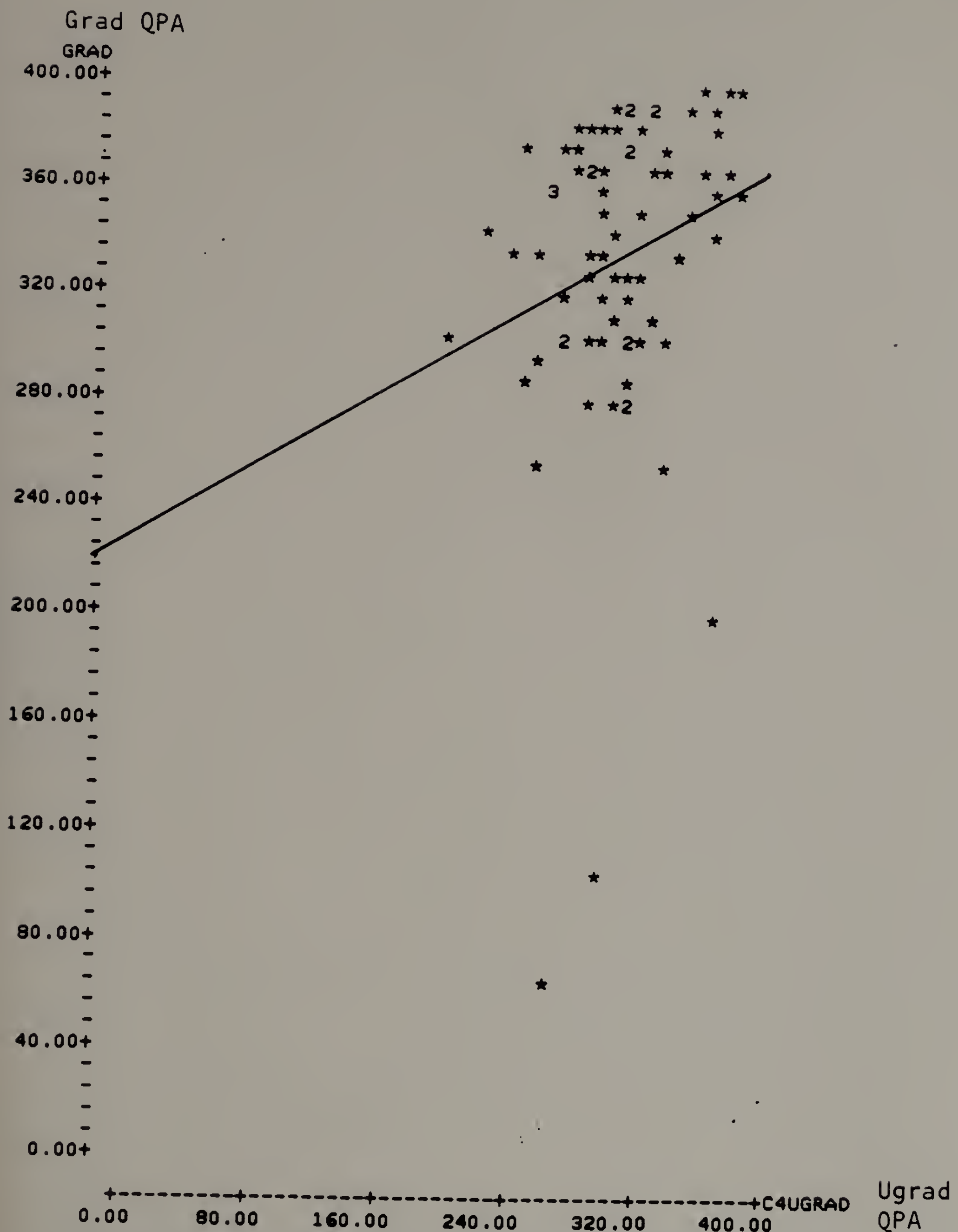
UNDERGRADUATE QUALITY POINT AVERAGE AND PERFORMANCE

Gross Regression Analysis

Sample Size	83
Formula:	Grad = 219 + (0.381) (UGRAD)
r squared:	6.1
r squared Adjusted for DF:	4.8
F=1.99	
*N*ot Significant	

PLOT #26

UNDERGRADUATE QPA VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #4



Graduate QPA = 219 = .381 Undergraduate QPA
Correlation: .246
r squared: 6.1%

TABLE #56A

Description: Undergraduate QPA (Stratified)

Category #4	ALL	Grad Quality Point Ave for Ugrad QPA 0-3.00	Ugrad QPA 3.01-3.50	Ugrad QPA 3.51-4.00
Sample Size	83	34	32	11
Mean	3.347	3.229	3.397	3.616
Median	3.450	3.370	3.385	3.710
StDev	.603	.705	.417	.569
Corr. to Grad QPA	.246	.091	.115	.230
_r_ squared	6.1	0.8	1.3	5.3
_r_ squared Ad DF	4.8	0	0	0
_F_	4.84	0.27	0.41	0.50
Level of Sig	.05	No	No	No

Analysis of Variance:
Undergraduate Quality Point Average
as a Determinent for Performance

```
                Mean          Individual 95% CI for Mean
Ugrad           Grad          Based on Pooled StDev
 QPA         N  QPA    StDev---------+---------+---------+-------
0-3.00      34 3.229   .705(------*-----)
3.01/50     32 3.397   .417     (------*------)
3.51/400    11 3.616   .569        (-----------*----------)
                           ---------+---------+---------+------
Performance (Grad QPA)         3.30      3.60      3.90
F=1.99:  Not Significant
```

Summary: The undergraduate quality point average is not a significant predictor of graduate performance for on-campus IEOR degree students. Though a trend exists indicating increased graduate performance with higher undergraduate grades, the relationship between undergraduate and graduate variations is not significant.

ANALYSIS OF VARIABLES AGAINST PERFORMANCE OF OFF-CAMPUS ENGINEERING MANAGEMENT DEGREE STUDENTS

CATEGORY #5

OFF-CAMPUS VIDEO-BASED DEGREE STUDENTS
ENGINEERING MANAGEMENT CONCENTRATION
DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

Off-campus IEOR degree students participating in the video-based Engineering Management program were generally five years older then on-campus graduate students (31 versus 26), and had a mean degree age two years older than those of the resident graduate students (5 versus 3). The off-campus students had higher mean scores on the GRE verbal (505 versus 468) and quantitative (642 versus 627) tests. On-campus students had a slightly higher score in the analytic test (545 versus 537) and had undergraduate grade point averages .031 higher. Similar to the results comparing the on versus off-campus students in Electrical and Computer Engineering, the off-campus Engineering Management degree students out-performed their on-campus counterparts with a graduate QPA of 3.41 to 3.35.

Student age proved a significant variable for on-campus Industrial Engineering/Operations Research students. This was not the case in off-campus Engineering Management enrollees where chronological age, when corrected for degrees of freedom, did not act as a predictor on any part of the sample. On-campus, age was a predictor for 11.4% of the population (10.4 corrected for degrees of freedom).

Though statistically insignificant, age exhibited a .411 correlation to performance in the 31 to 35 student age group. However, in the next strata, with ages 36 and above, the (insignificant) correlation dropped to -.296. This might again reflect the age sensitivity of students quantitative skills.

This correlations was also observed between degree age and graduate performance. When students were from 2 to 5 years beyond their undergraduate program, the correlation to graduate quality point average was .355. The correlation for students whose degree ages were six to ten years old dropped to -.054. While both were insignificant, they dovetail with information observed for the on-campus IEOR students. In that category, the (insignificant) correlation to performance by degree age in the two to three year old category was .120. When the degrees were older than three years, the correlation to performance plummeted to -.361. Again, the caveat is in place which warns that these data are not statistically significant. Further, the above is inconsistent with the (insignificant) analysis of variance which showed that as the age of the degree rose, so did performance. Again, the data is unreliable in this instance.

The GRE Verbal test score for Engineering Management degree students was significantly (.05 level) correlated with performance (.297). In fact, when all variables were regressed in a stepwise fashion against these students' performance, the GRE Verbal was noted as having the key relationship. While the analysis of variance proved insignificant, a clear trend was evidenced which indicated higher performance with higher scores on the verbal test.

Results on the GRE Quantitative test proved statistically insignificant when tested for changes in on-campus student performance. On the other hand, results were significant for off-campus Engineering Management students. The correlation of GRE quantitative scores to graduate quality point average was .303 (significant to the .05 level) and when regressed, accounted for 13.1% of the population (11.5% when corrected). This proved significant to the .01 level. The highest correlation of GRE to performance was in that group with quantitative scores ranging from 601 to 700. Albeit statistically insignificant, the correlation was .442.

This category's analysis of variance also proved insignificant.

Variations in scores on the analytic test did prove significant, to the .01 level, in accounting for changes in graduate performance. Though not significant on-campus, the correlation between GRE analytic scores and performance for off-campus enrollees was .362. When regressed against performance, the test accounted for 13.1% of the population (11.5% when adjusted for degrees of freedom).

The analysis of variance for the GREA also proved significant to the .01 level while its Scheffe did not evidence statistically significant differences within variable. There was little difference among students in this category who scored from 501 to 600 on this test (mean graduate quality point average of 3.55) from those who tested at the 601 to 700 level (mean graduate average of 3.54).

The undergraduate quality point average proved totally insignificant and inconsequential in terms of trends.

OFF-CAMPUS ENGINEERING MANAGEMENT DEGREE STUDENTS

TABLE #57

SUMMARY DESCRIPTION

Category #5	Age	Degree Age	Graduate Verbal	Record Quant	Exam Analy	Ugrad QPA	Grad QPA
Sample Size	66	67	55	55	55	52	66
Mean	31.32	5.10	505.0	641.6	537.0	2.750	340.6
Median	30.00	4.00	490.0	630.0	540.0	2.740	3.500
StDev	6.00	5.46	105.0	81.9	115.0	.498	.467

INTERACTIVE CORRELATIONS

Category #5	Age	Degree Age	Graduate Verbal	Record Quant	Exam Analy	Ugrad QPA
Degree Age	.441					
GRE Verb	.020	.232				
GRE Quant	-.340	.194	.396			
GRE Anal	-.372	.019	.642	.546		
Ugrad QPA	-.300	-.122	.127	.153	.083	
Grad QPA	-.122	.105	.297	.303	.362	.062

TABLE #58

AGE AND PERFORMANCE

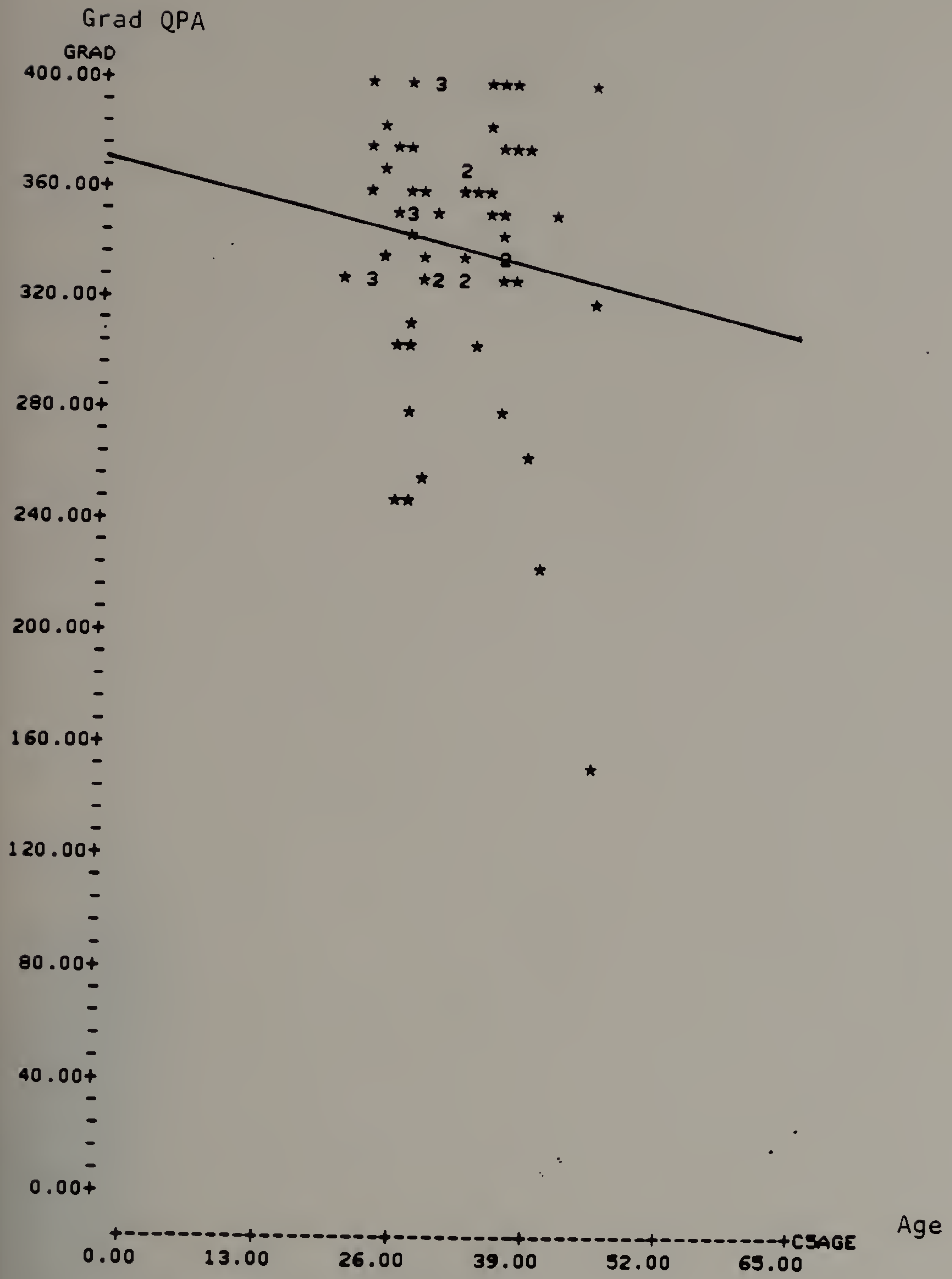
Gross Regression Analysis

Sample Size	66
Formula:	Grad = 371 - (0.957) (Age)
$\underline{r}$ squared:	1.5
$\underline{r}$ squared Adjusted for DF:	0

$\underline{F}$=0.94
Not Significant

PLOT #27

AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #5



Graduate QPA = 371 - 0.957 Age
Correlation: -.122
r squared: 1.5%

TABLE #58A

Description: Age (Stratified)

Category #5	ALL	Grad Quality Point Ave for Age 20-25	Age 26-30	Age 31-35	Age 36 +
Sample Size	66	10	25	12	18
Mean	3.406	3.539	3.372	3.539	3.298
Median	3.500	3.495	3.500	3.600	3.395
StDev	.467	.276	.451	.272	.649
Corr. to Grad QPA	-.122	.320	.296	.411	-.296
r squared	1.5	10.3	8.8	16.9	8.8
r squared Adj DF	0	0	4.8	8.6	3.1
F	.096	0.92	2.21	2.04	1.54
Level of Sig	No	No	No	No	No

Analysis of Variance: Age as a Determinent for Performance

```
            Mean
            Grad            Individual 95% CI for Mean
                            Based on Pooled StDev
Age     N   QPA   StDev     --+---------+---------+---------+----
20-25  10 3.539   .276            (-----------*------------)
26-30  25 3.372   .451          (------*-------)
31-35  12 3.539   .272             (----------*-----------)
36 +   18 3.298   .649      (---------*---------)
                            --+---------+---------+---------+----
Performance (Grad QPA)     3.12      3.36      3.60      3.84
F=0.94:   Not Significant
```

Summary: Student age is not a statistically significant predictor of performance among Engineering Management degree students. Variations in student age are not statistically related to variation in graduate performance

TABLE #59

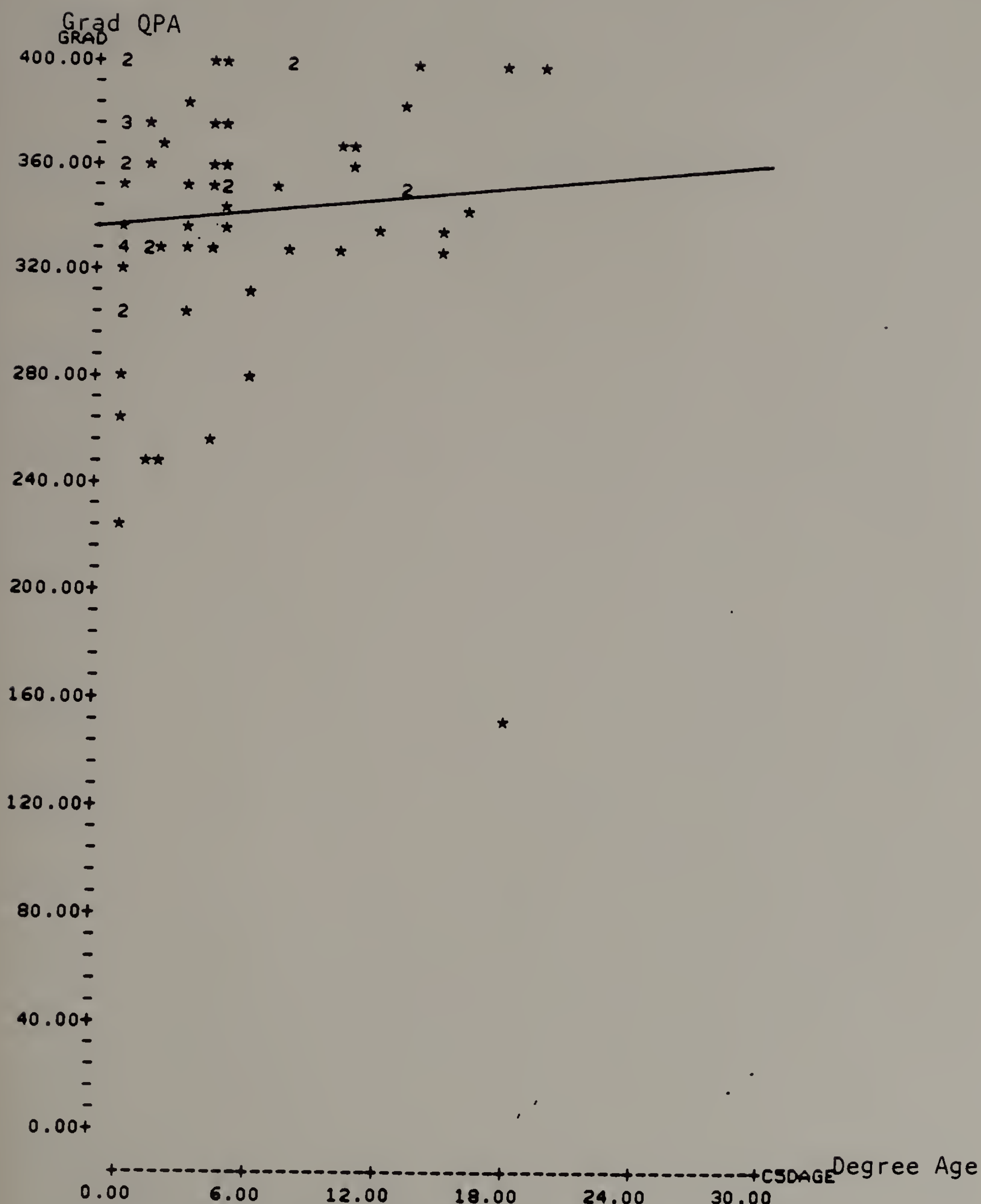
DEGREE AGE AND PERFORMANCE

Gross Regression Analysis

Sample Size	66
Formula:	Grad = 336 + (0.90) (Deg Age)
r squared:	1.1
r squared Adjusted for DF:	0
F=0.5	
Not Significant	

PLOT #28

DEGREE AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #5



Graduate QPA = 336 + .90 Degree Age
Correlation: .105
r squared: 1.1%

TABLE #59A

Description: Degree Age (Stratified)

Category #5	ALL	Grad Quality Point Ave for Degree Age 0-1	Degree Age 2-5	Degree Age 6 +
Sample Size	66	24	21	21
Mean	3.406	3.324	3.439	3.465
Median	3.500	3.300	3.500	3.500
StDev	.467	.451	.392	.556
Corr. to Grad QPA	.105	-.047	.355	-.054
_r_ squared	1.1	0.2	12.6	0.3
_r_ squared Adj DF	0	0	8.0	0
_F_	0.72	0.05	2.74	0.16
Level of Sig	No	No	No	No

Analysis of Variance:
Degree Age as a Determinent for Performance

```
                 Mean
Degree           Grad           Individual 95% CI for Mean
                                Based on Pooled StDev
 Age      N      QPA    StDev   -----+---------+---------+---------+-
 0-1     24    3.324    .451     (-----------*-----------)
 2-5     21    3.439    .392           (------------*------------)
 6 +     21    3.465    .556             (------------*-----------)
                                -----+---------+---------+---------+-
Performance (Grad QPA)             3.20      3.36      3.52      3.68
F=0.58:  Not Significant
```

Summary: Degree age is not a statistically significant predictor for Engineering Management student graduate performance. Though trends indicate increased degree age leading to increased performance, variations in degree age are not statistically related to variations in graduate performance.

TABLE #60

GRADUATE RECORD EXAMINATION VERBAL TEST AND PERFORMANCE

Gross Regression Analysis

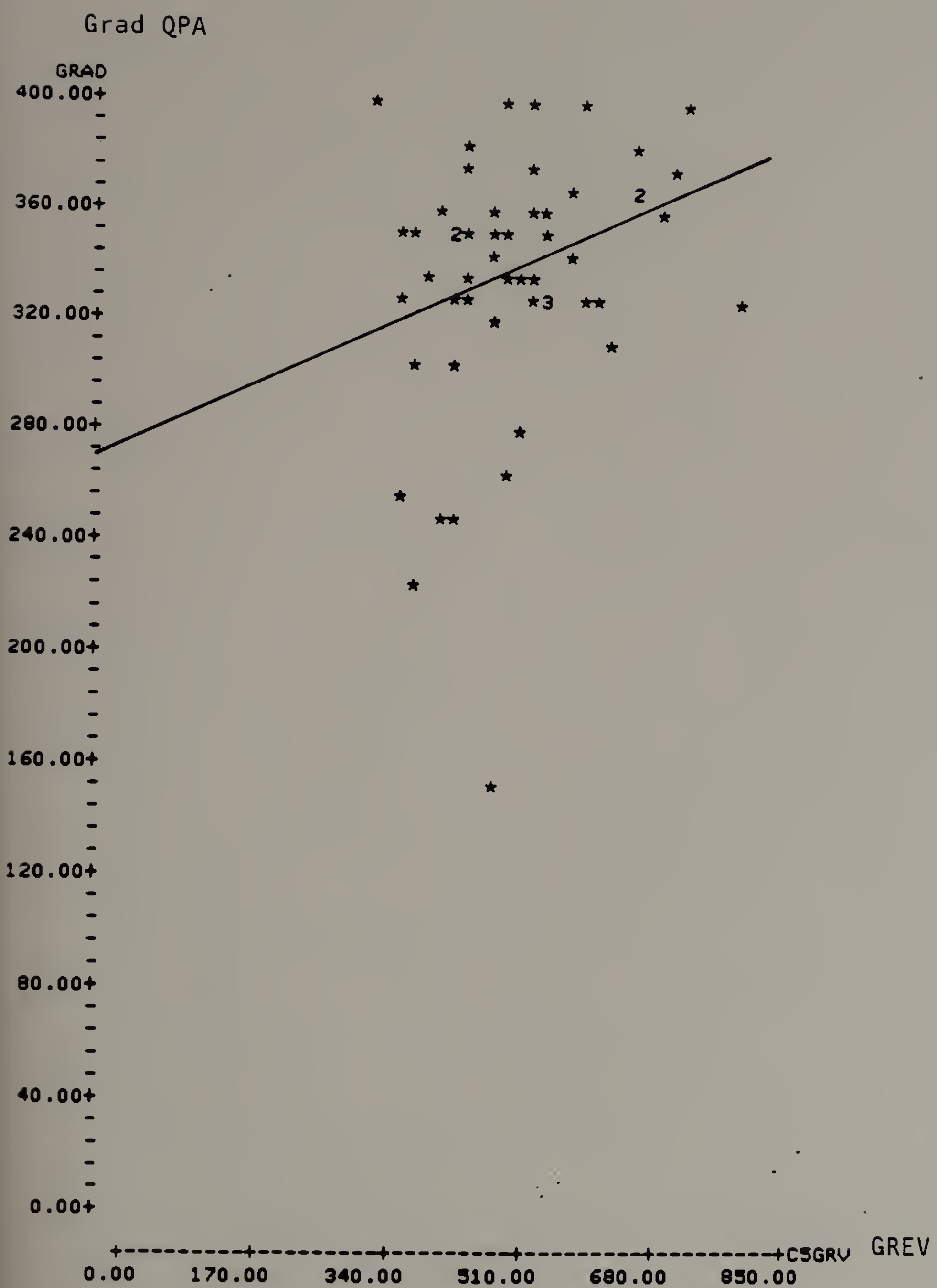
Sample Size	66
Formula:	Grad = 270 + (0.0132) (GREV)
r squared:	8.8
r squared Adjusted for DF:	7.1

F=2.02

*N*ot Significant

PLOT #29

GRE VERBAL VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #5



Graduate QPA = 270 + .132 GREV
Correlation: .297
r squared: 8.8%

TABLE #60A

Description: GRE Verbal Test (Stratified)

Category #5	ALL	Grad Quality Point Ave for GRE Verbal 0-400	GRE Verbal 401-500	GRE Verbal 501-600	GRE Verbal 601 +
Sample Size	66	9	20	16	9
Mean	3.406	3.110	3.291	3.472	3.574
Median	3.500	3.300	3.450	3.395	3.660
StDev	.467	.572	.552	.303	.297
Corr. to Grad QPA	.297	-.551	-.053	.298	.219
_r_ squared	8.8	30.3	0.3	8.9	4.8
_r_ squared Ad DF	7.1	20.4	0	2.4	0
_F_	5.05	3.04	0.05	1.37	0.35
Level of Sig	.05	No	No	No	No

Analysis of Variance:
Graduate Record Examination Verbal as a Determinent for Performance

```
            Mean           Individual 95% CI for Mean
 GRE        Grad           Based on Pooled StDev
Verbal N    QPA   StDev    -------+---------+----------+--------
0-400    9 3.110  .572     (----------*---------)
401-5/  20 3.291  .552              (------*------)
501-6/  16 3.472  .303                   (-------*------)
601 +    9 3.574  .297                    (---------*---------)
                           -------+---------+----------+--------
Performance (Grad QPA)        3.00      3.30       3.60
F=2.02:  Not Significant
```

Summary: Performance on the GRE Verbal test is not a statistically significant performance predictor among Engineering Management degree students. Though a trend exists indicating that higher GREV scores result in higher graduate performance, a statistically significant relationship does not exist between scores and performance.

TABLE #61

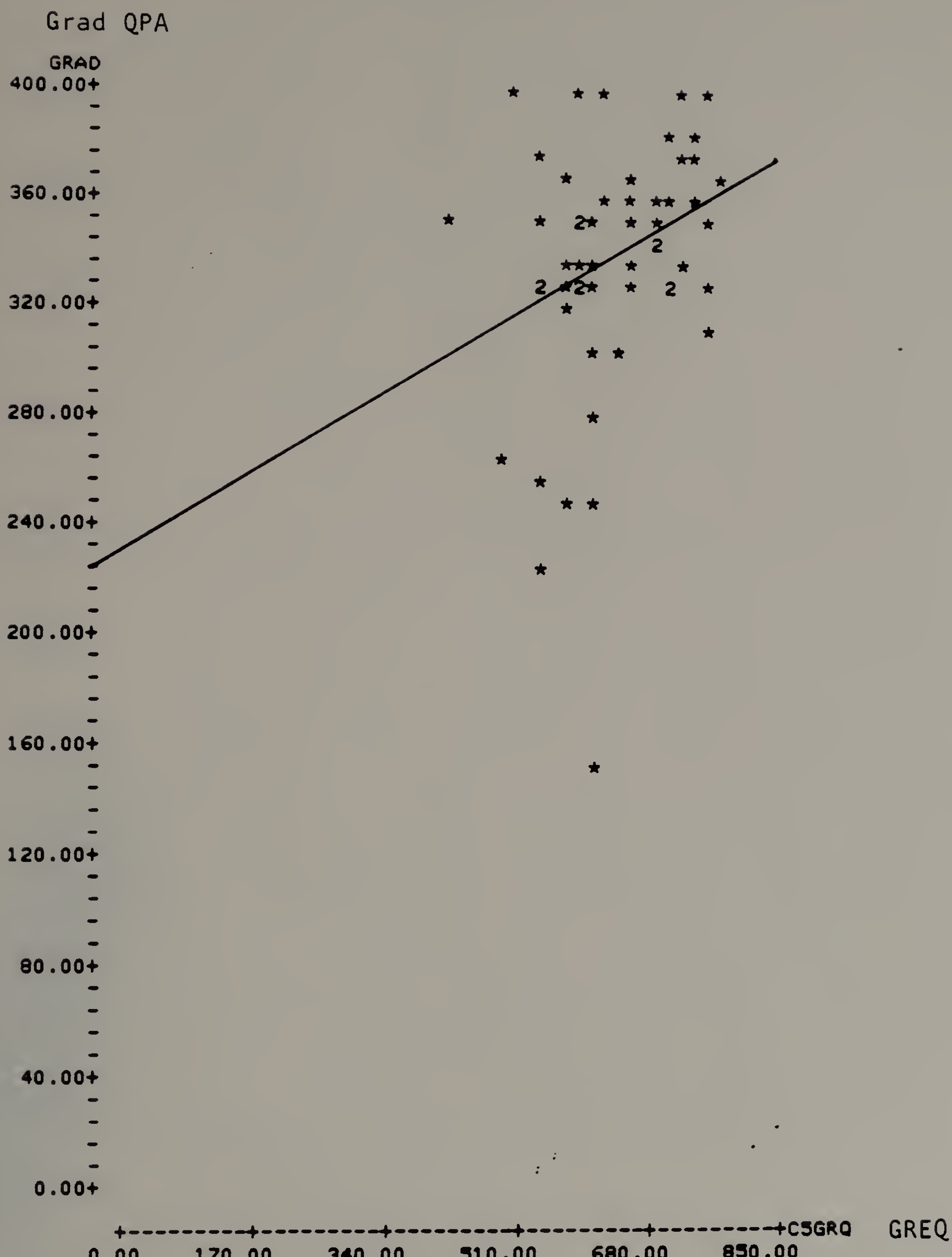
GRADUATE RECORD EXAMINATION QUANTITATIVE TEST AND PERFORMANCE

Gross Regression Analysis

Sample Size	66
Formula:	Grad = 224 + (0.176) (GREQ)
r squared:	9.2
r squared Adjusted for DF:	7.4
F=2.70	
Not Significant	

PLOT #30

GRE QUANTITATIVE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #5



Graduate QPA = 224 + 0.176 GREQ
Correlation: .303
r squared: 9.2%

TABLE #61A

Description: GRE Quantitative Test (Stratified)

Category #5	ALL	Grad Quality Point Ave for GRE Quant 0-600	GRE Quant 601-700	GRE Quant 701 +
Sample Size	66	20	19	15
Mean	3.406	3.286	3.259	3.594
Median	3.500	3.330	3.400	3.620
StDev	.467	.471	.544	.279
Corr. to Grad QPA	.303	.038	.442	-.047
r squared	9.2	0.1	19.5	0.2
r squared Ad DF	7.4	0	14.8	0
F	5.26	0.03	4.13	0.03
Level of Sig	.05	No	No	No

Analysis of Variance:
Graduate Record Examination Quantitative
as a Determinent for Performance

```
             Mean           Individual 95% CI for Mean
 GRE         Grad           Based on Pooled StDev
Quant   N    QPA    StDev   ---+---------+---------+---------+---
0-600   20 3.286   .471      (--------*-------)
601-7/  19 3.259   .544     (--------*--------)
701 +   15 3.594   .279                 (---------*---------)
                            ---+---------+---------+---------+---
Performance (Grad QPA) 3.12      3.36      3.60      3.84
F=2.70:  Not Significant
```

Summary: GRE Quantitative test scores do not offer a statistically significant performance predictor for off-campus Engineering Management degree students, nor are variations in GREQ test scores statistically related to variations in student performance.

TABLE #62

GRADUATE RECORD EXAMINATION ANALYTIC TEST AND PERFORMANCE

Gross Regression Analysis

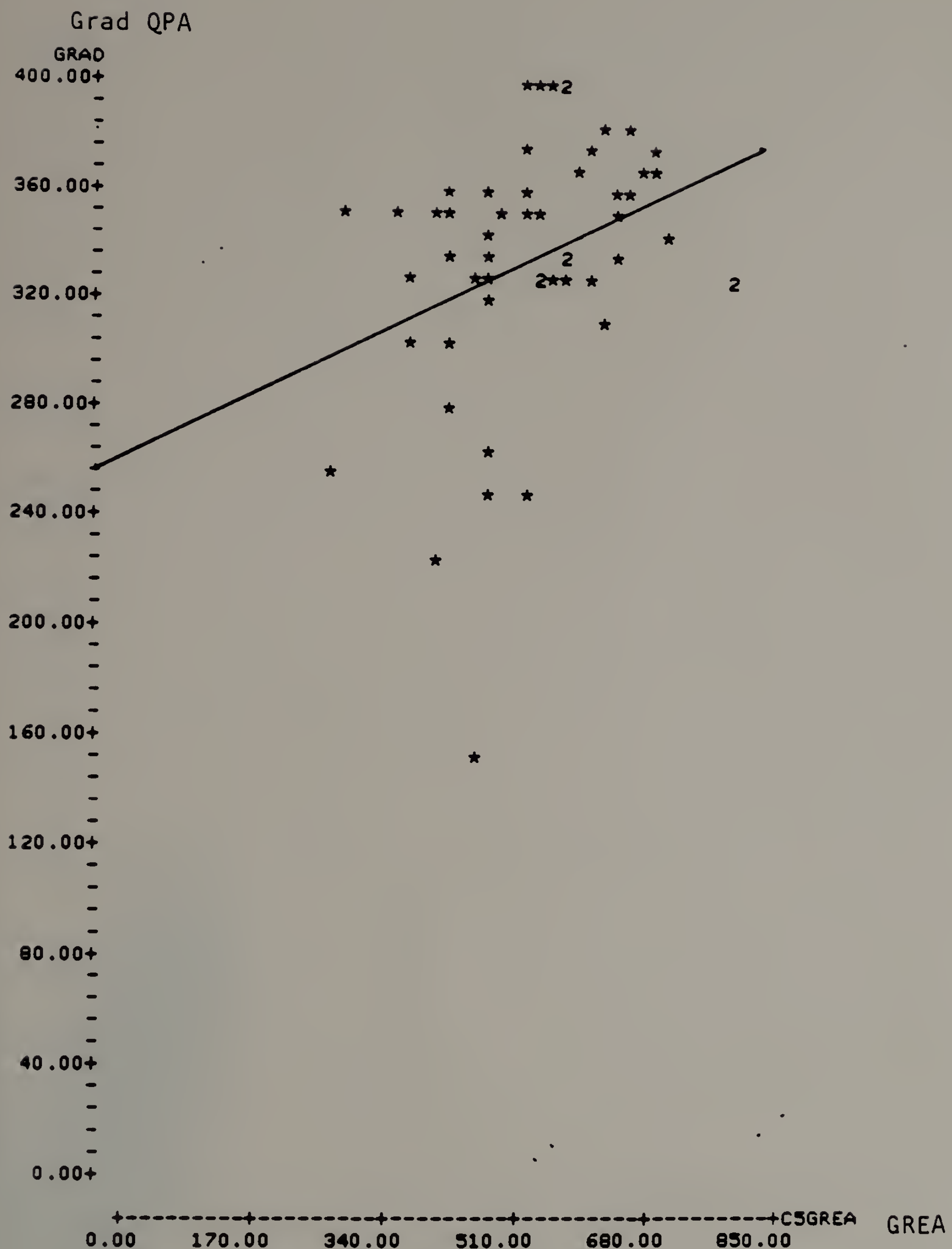
Sample Size	66
Formula:	Grad = 256 + (0.149) (GREA)
r squared:	13.1
r squared Adjusted for DF:	11.5

F=7.14

Significant to the .01 level

PLOT #31

GRE ANALYTIC VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #5



Graduate QPA = 256 + 0.149 GREA
Correlation: .362
r squared: 13.1%

TABLE #62A

Description: GRE Analytic Test (Stratified)

		Grad Quality Point Ave for		
Category #5	ALL	GRE Analy 0-500	GRE Analy 501-600	GRE Analy 601 +
Sample Size	66	22	17	15
Mean	3.406	3.099	3.548	3.537
Median	3.500	3.290	3.500	3.620
StDev	.467	.527	.402	.234
Corr. to Grad QPA	.362	.007	.221	-.318
r squared	13.1	0	4.9	10.1
r squared Ad DF	11.5	0	0	3.2
F	7.86	0.00	0.77	1.46
Level of Sig	.01	No	No	No

Analysis of Variance:
Graduate Record Examination Analytic
as a Determinent for Performance

```
             Mean           Individual 95% CI for Mean
 GRE         Grad           Based on Pooled StDev
Analy   N   QPA    StDev   ---------+---------+---------+-------
0-500   22 3.099   .527     (------*-------)
501-6/  17 3.548   .402                    (--------*-------)
601 +   15 3.537   .234                   (--------*---------)
                           ---------+---------+---------+-------
Performance (Grad QPA)         3.12      3.36      3.60
```

F=7.14: Significant at the .01 Level

Note: Significant differences exist in performance between students with a test score range of 0-500 and 501-600 and from 0-500 and above 600 on the GREA. Significant differences are not found in the performance of those students with GREA test scores of 501-600 and those above 600.

Summary: Performance on the GRE Analytic test is a significant predictor for graduate performance among Engineering Management degree students. Variations among GREA test scores do significantly account for variation in graduate performance. Students scoring below 500 on the GREA perform significantly differently from those with higher scores. There is no significant performance variation between student scoring between 501 to 600 and those scoring above 600.

TABLE #63

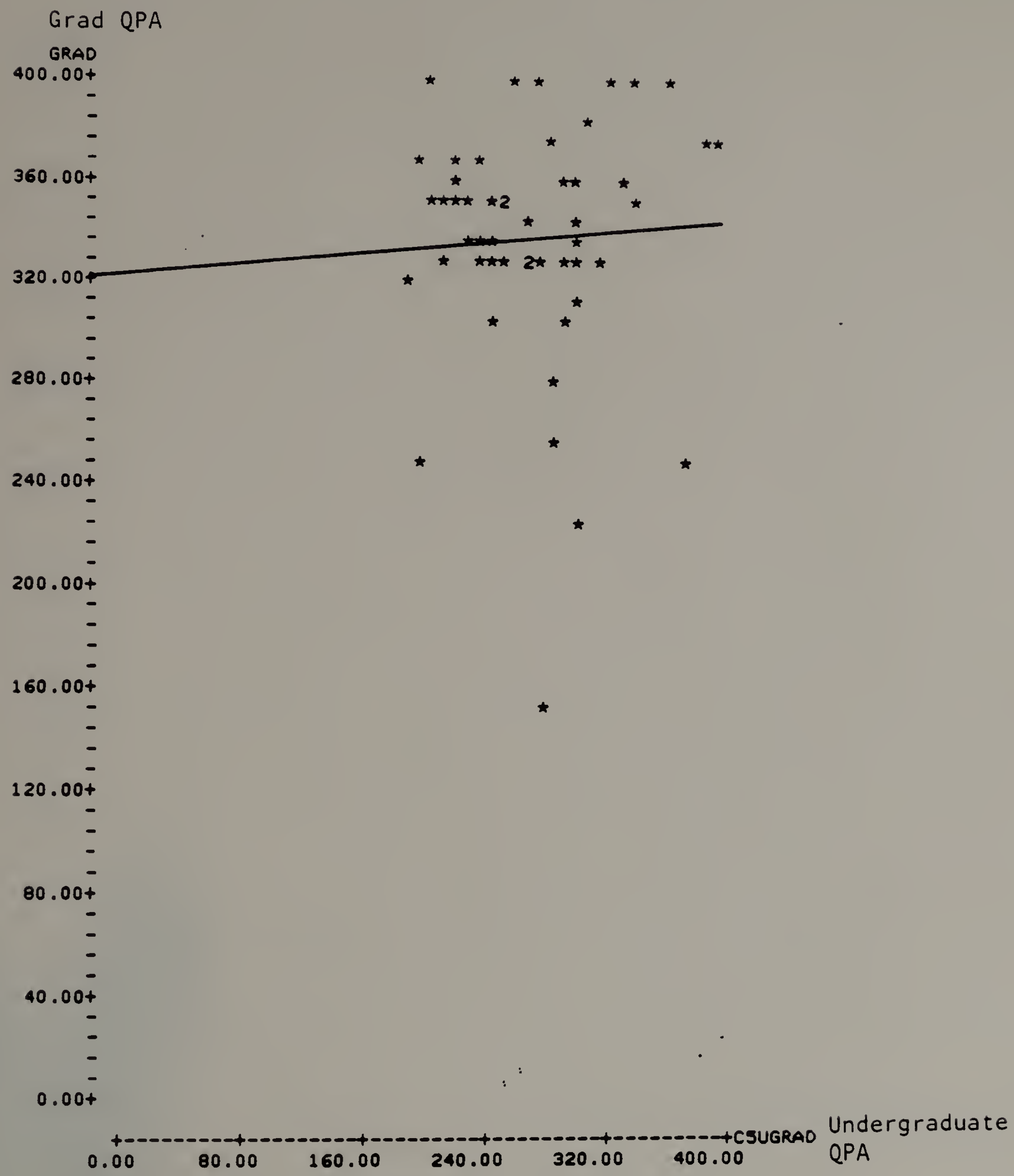
UNDERGRADUATE QUALITY POINT AVERAGE AND PERFORMANCE

Gross Regression Analysis

Sample Size	66
Formula:	Grad = 321 + (0.059) (UGRAD)
_r_ squared:	0.4
_r_ squared Adjusted for DF:	0
_F_=2.38	
Not Significant	

PLOT #32

UNDERGRADUATE QPA VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #5



Graduate QPA = 321 + 0.059 Undergraduate QPA
Correlation: .062
r squared: 0.4%

TABLE #63A

Description: Undergraduate QPA (Stratified)

Category #5	ALL	Grad Quality Point Ave for Ugrad QPA 0-2.50	Ugrad QPA 2.51-3.00	Ugrad QPA 3.00-4.00
Sample Size	66	19	18	14
Mean	3.406	3.414	3.196	3.548
Median	3.500	3.500	3.275	3.590
StDev	.467	.314	.613	.409
Corr. to Grad QPA	.062	-.017	-.272	.122
r squared	0.4	0	7.4	1.5
r squared Ad DF	0	0	1.6	0
F	0.19	0	1.28	0.18
Level of Sig	No	No	No	No

Analysis of Variance:
Undergraduate Quality Point Average
as a Determinent for Performance

```
             Mean        Individual 95% CI for Mean
Ugrad        Grad        Based on Pooled StDev
 QPA       N QPA    StDev------+---------+---------+---------+
0-2.50    19 3.414 .314         (--------*--------)
2.51/300  18 3.196 .613 (--------*--------)
3.01/400  14 3.548 .409             (----------*---------)
                        ------+---------+---------+---------+
Performance (Grad QPA)    3.12      3.36      3.60      3.84
F=2.38:  Not Significant
```

Summary: The undergraduate quality point average is not a statistically significant predictor of graduate performance among Engineering Management degree students nor are variations in undergraduate performance statistically related to changes in graduate quality point average.

ANALYSIS OF VARIABLES
OFF-CAMPUS NON-DEGREE INDUSTRIAL ENGINEERING/OPERATIONS
RESEARCH STUDENTS

CATEGORY #6

OFF-CAMPUS VIDEO-BASED NON-DEGREE STUDENTS DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

A student's chronological age was the only available variable for off-campus non-degree students enrolled in Industrial Engineering/Operations Research courses through the Videotape Instructional Program. It proved totally insignificant in accounting for changes in graduate performance and no trends were evident.

Clearly, other factors are at work in impacting upon these students' performance.

TABLE #64

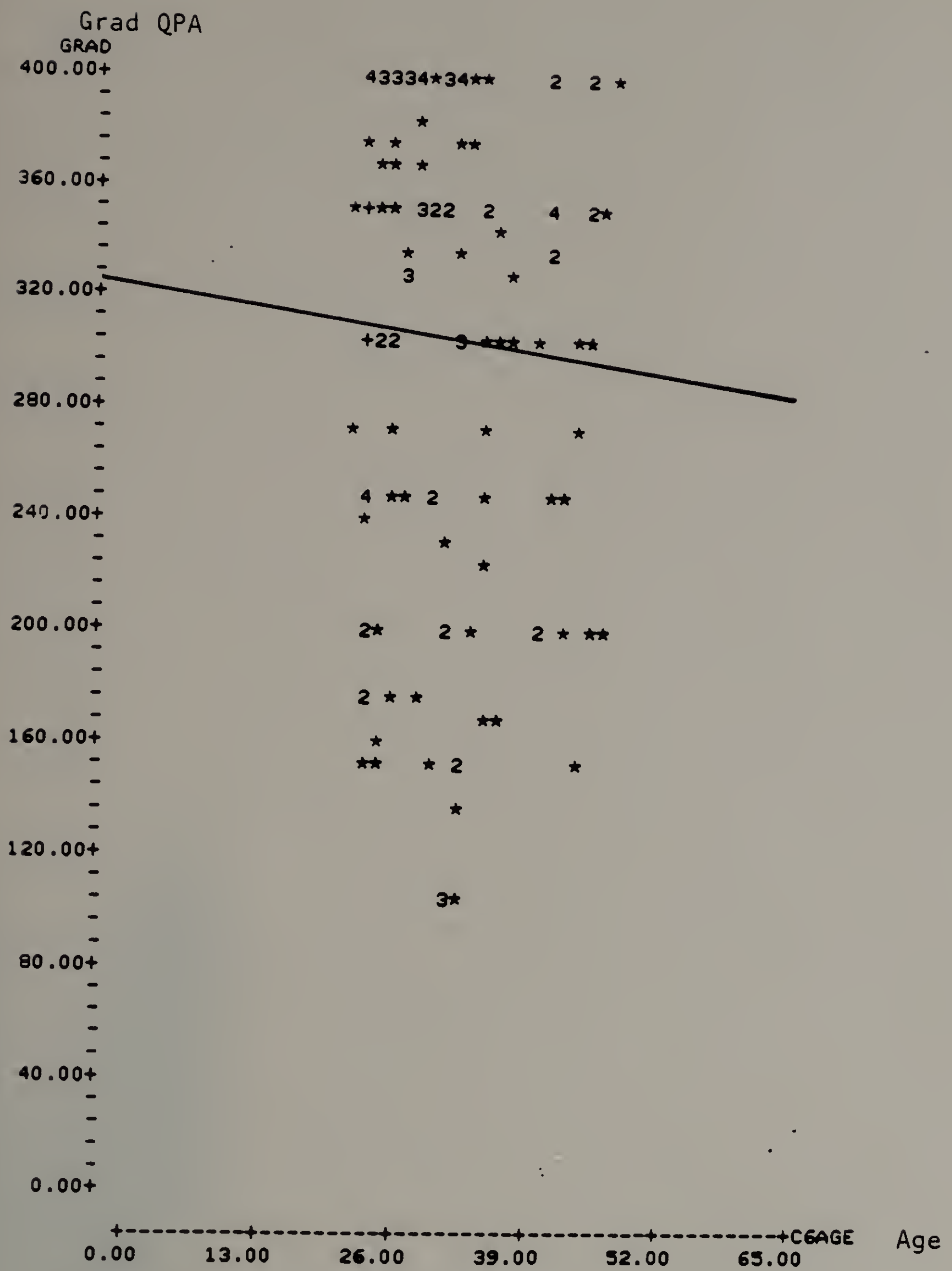
AGE AND PERFORMANCE

Gross Regression Analysis

Sample Size	152
Formula:	Grad = 325 - (0.610) (Age)
r squared:	0.3
r squared Adjusted for DF:	0
F=0.40	
Not Significant	

PLOT #33

AGE VERSUS GRADUATE QPA FOR STUDENTS IN CATEGORY #6



Graduate QPA = 325 - .610 Age
Correlation: -.052
r squared: 0.3%

TABLE #64A

Description: Age (Stratified)

Category #6	Grad Quality Point Ave for ALL	Age 20-25	Age 26-30	Age 31-35	Age 36 +
Sample Size	152	49	35	35	31
Mean	3.065	3.054	3.336	2.820	3.026
Median	3.330	3.000	3.500	3.000	3.350
StDev	.831	.727	.716	1.070	.746
Corr. to Grad QPA	-.052	-.024	-.119	.085	.155
r squared	0.3	0.1	1.4	0.7	2.4
r squared Adj DF	0	0	0	0	0
F	0.40	0.03	0.47	0.24	0.72
Level of Sig	No	No	No	No	No

Analysis of Variance: Age as a Determinent for Performance

```
             Mean             Individual 95% CI for Mean
             Grad             Based on Pooled StDev
 Age     N   QPA    StDev     ------+---------+---------+---------+
20-25   49 3.054   .727                (-------*-------)
26-30   35 3.336   .716                        (--------*--------)
31-35   35 2.821  1.075        (--------*--------)
36 +    31 3.026   .746              (---------*---------)
                              ------+---------+---------+---------+
Performance (Grad QPA)          2.70      3.00      3.30      3.60
```

F=2.32: Not Significant

Summary: Age is not a statistically significant predictor of performance for off-campus non-degree IEOR graduate students. Variations in student age does not statistically relate to variation in graduate performance.

RELATIONSHIP BETWEEN ACTUAL AND PREDICTED GRADUATE PERFORMANCE BETWEEN AND AMONG ON AND OFF-CAMPUS DEGREE STUDENTS IN ELECTRICAL AND COMPUTER ENGINEERING

> There is no statistically significant relationship between the predicted and actual graduate quality point averages of on-campus students in Electrical and Computer Engineering and off-campus video-based Electrical and Computer Engineering graduate students.

Results from stepwise regression analyses were used to develop the best possible predicted graduate grade point average given available variables.

For on-campus graduate students in the Department of Electrical and Computer Engineering, the stepwise regression indicated that the key variable combination consisted of an amalgamation of degree age, GRE Quantitative test score, and undergraduate grade point average.

When graduate student performance was subjected to regression analysis against this combination of variables, the formula offering the strongest vitality was:

Predicted Performance = 82 + [(3.69)(Degree Age)] + [(1.28)(GRE Quantitative)] + [(0.461)(Undergraduate Quality Point Average)]

This model resulted in a correlation of .401 between actual and when subjected to regression analysis, accounted for 16.1% of the population (15.7 adjusted for degrees of freedom; "F"=37.23. It was significant to the .01 level). The following is offered for comparison.

TABLE #65

MEAN ACTUAL VERSUS PREDICTED GRADUATE PERFORMANCE
ON-CAMPUS DEGREE STUDENTS
ELECTRICAL AND COMPUTER ENGINEERING

	Actual Graduate QPA	Predicted Graduate QPA
N	219	214
Mean	3.248	3.261
Median	3.370	3.264
StDev	.569	.230
Max	4.000	3.958
Min	.660	2.649

When an analysis of variance was conducted to determine whether statistically significant differences existed between the actual and predicted values, the resulting "F" proved insignificant at 0.09.

TABLE #66

ON-CAMPUS ECE DEGREE STUDENTS
ACTUAL VERSUS PREDICTED GRADUATE PERFORMANCE

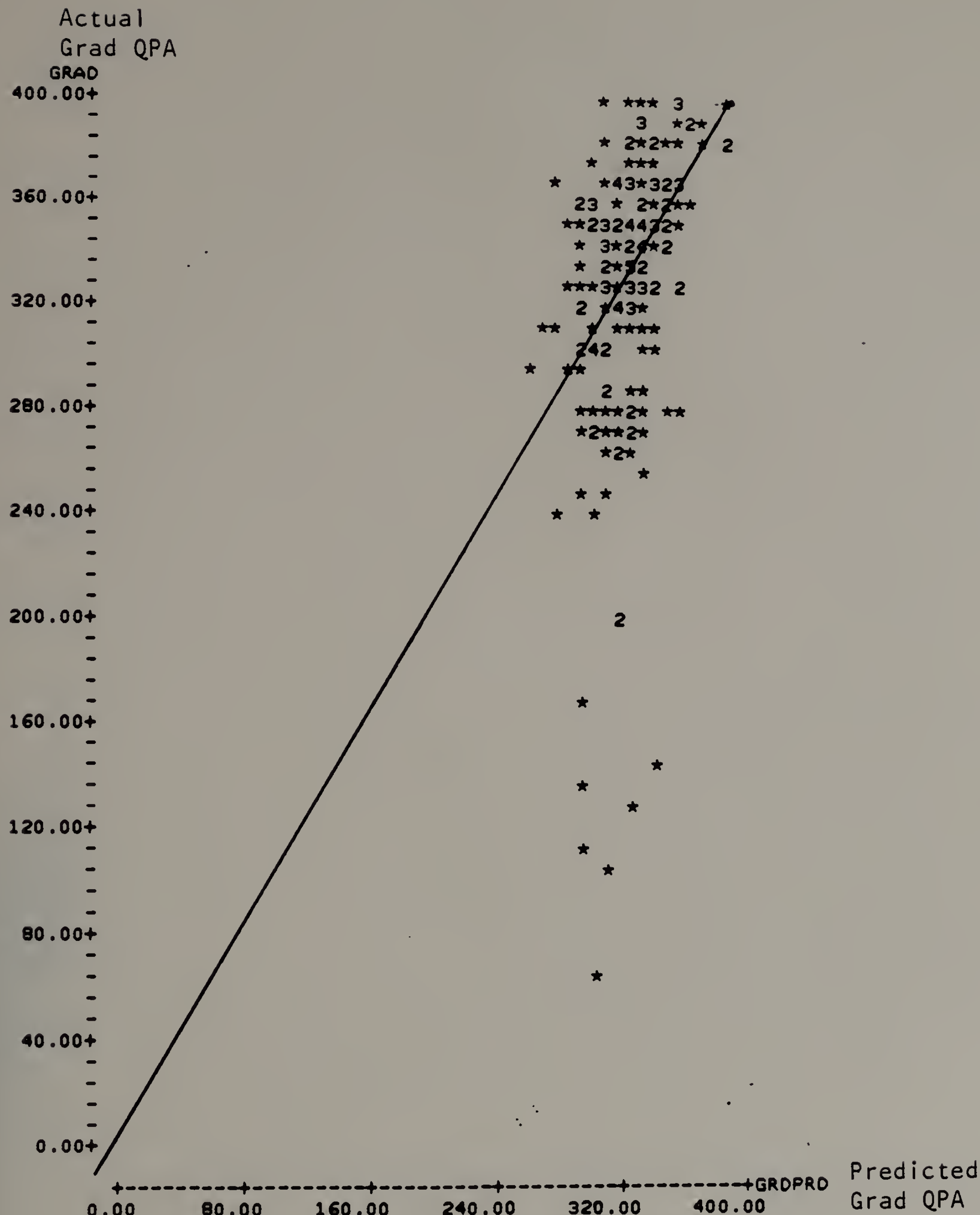
```
           Mean
           Grad            INDIVIDUAL 95% CI FOR MEAN
        N  QPA    StDev    BASED ON POOLED STDEV
                           ---+---------+---------+---------+---
Act'l 219 3.248   .569     (-------------*-------------)
Prdic 204 3.261   .230          (-------------*-------------)
                           ---+---------+---------+---------+---
                             3.20      3.24      3.28      3.32
F=0.09:    Not Significant
```

Summary: No statistically significant difference exists between the actual and predicted graduate performance for on-campus ECE degree students.

The following plot describes the interaction of actual versus predicted quality grade point averages for on-campus Electrical and Computer Engineering graduate students.

PLOT #34

ACTUAL GRADUATE QPA FOR STUDENTS IN CATEGORY #1
VERSUS
PREDICTED GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Predicted Graduate QPA = 82 + 3.69 Degree Age + 1.28 GREQ + 0.461 Ugrad
Correlation Actual QPA v. Predicted QPA: .401
r squared (predicted to actual): 16.1%

Before comparing off-campus (Category #2) performance to on-campus predictors for students in Category #1 which will result in an indication of the validity of performance by students studying through ITV as opposed to those studying "live" and on-campus, it would be useful to compare these students' actual performance to those predictors specific to its category. Recall that the stepwise regression for off-campus Electrical and Computer Engineering degree students indicated that the key variable consisted solely of scores of the Graduate Record Examination quantitative test. This resulted in the following formula for best predicted grades being for off-campus ECE degree students.

Predicted Performance = 204 + [(0.208)(GRE Quantitative)]

The following is the comparison noted between actual grades earned by off-campus degree students and the predicted grades determined through the regression.

TABLE #67

MEAN ACTUAL VERSUS MEAN PREDICTED PERFORMANCE
OFF-CAMPUS VIDEO-BASED
ELECTRICAL AND COMPUTER ENGINEERING
DEGREE STUDENTS

	Actual Graduate QPA	Predicted Graduate QPA
N	84	73
Mean	3.441	3.457
Median	3.500	3.496
StDev	.507	.153
Max	4.000	3.766
Min	1.750	3.018

When an analysis of variance was conducted to determine whether statistically significant differences existed between the actual and predicted values, the resulting "F" proved insignificant at 0.07.

TABLE #68

OFF-CAMPUS ECE DEGREE STUDENTS
ACTUAL VERSUS PREDICTED PERFORMANCE

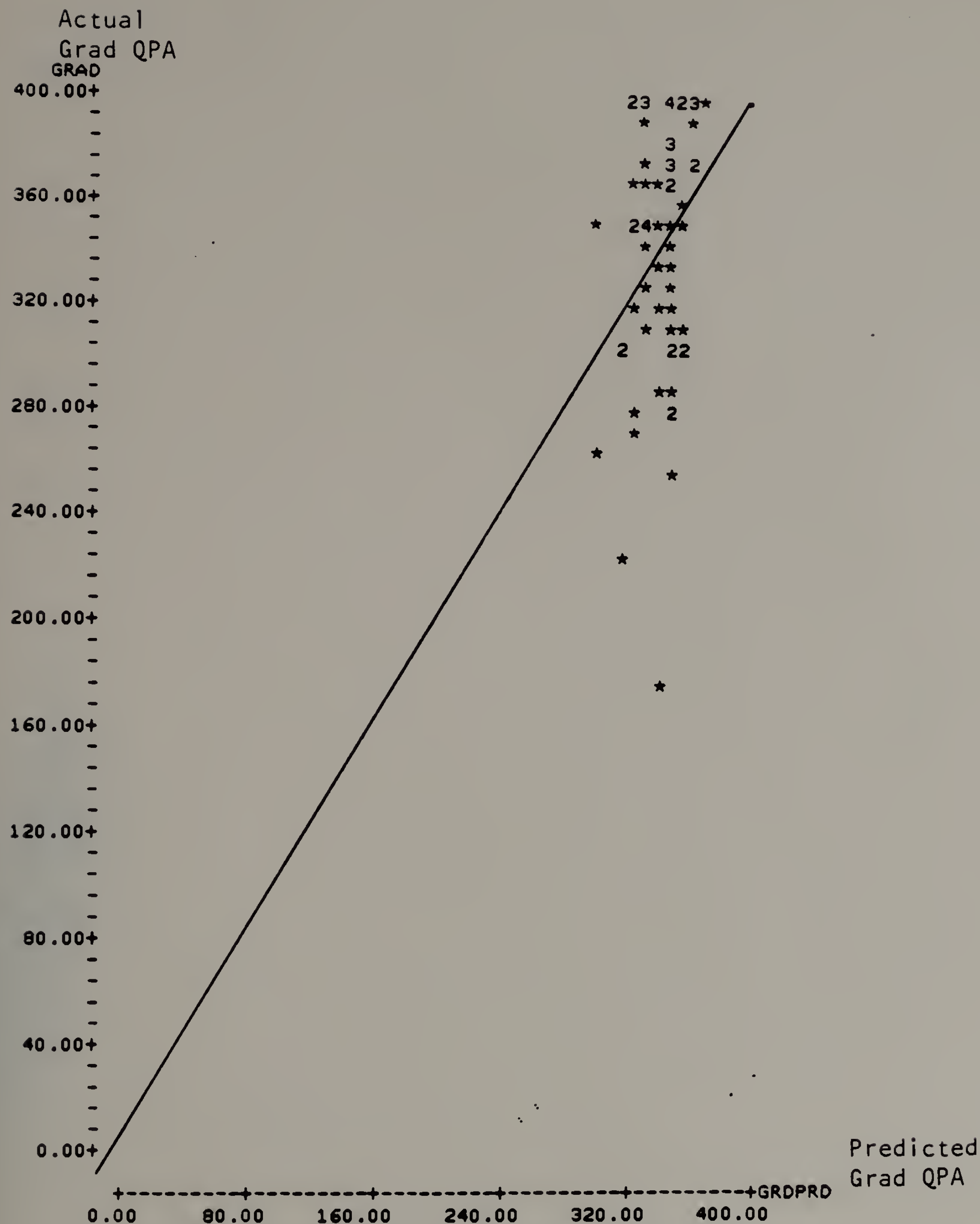
```
            Mean             INDIVIDUAL 95% CI FOR MEAN
            Grad             BASED ON POOLED STDEV
         N  QPA    StDev     -+---------+---------+---------+-----
Act'l   84  3.441   .507      (------------*-------------)
Prdic   73  3.457   .153       (--------------*--------------)
                             -+---------+---------+---------+-----
                           3.36      3.42      3.48      3.54

F=0.07:    Not Significant
```

Summary: Variations between actual and predicted performance among off-campus ECE degree students are insignificant. Analysis of variance does not reject the notion that no significance variation exists between actual and predicted graduate performance.

The following plot describes the interaction of actual versus predicted quality grade point averages for off-campus Electrical and Computer Engineering graduate students. Note that the correlation between predicted and actual grade point averages for off-campus degree students is .316 and when regressed, predicts 10.0% of the relationship (8.7% when adjusted for degree of freedom). The resulting "<u>F</u>", 7.55, is significant to .01.

PLOT #35

ACTUAL GRADUATE QPA FOR STUDENTS IN CATEGORY #2
VERSUS
PREDICTED GRADUATE QPA FOR STUDENTS IN CATEGORY #2

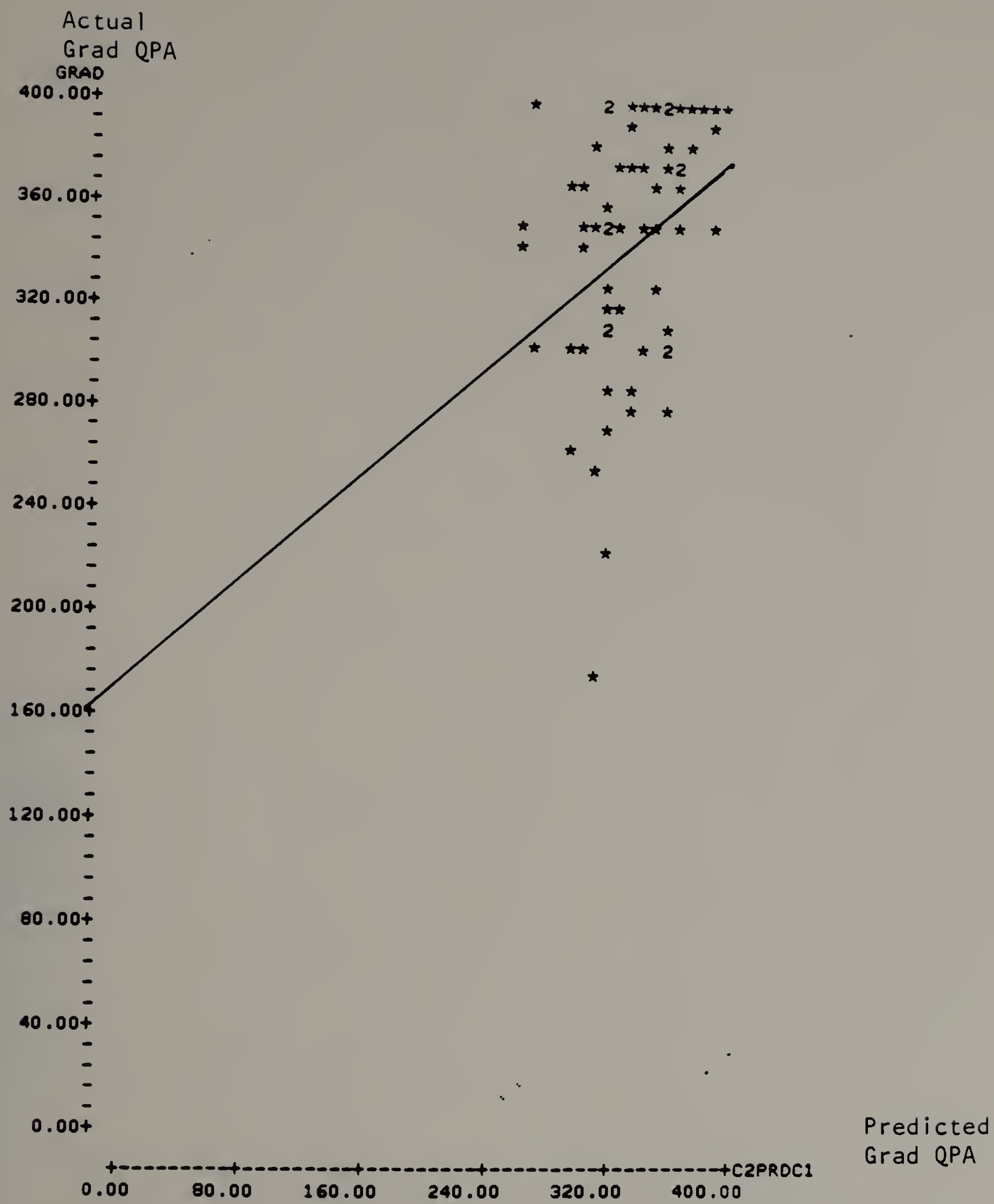


Predicted Graduate QPA = 204 + 0.208 GREQ
Correlation Actual QPA v. Predicted QPA: .316
r squared (predicted to actual): 10.0%

When actual performance for off-campus Electrical and Computer Engineering graduate students is plotted against the on-campus graduate student predictive model, the following plot is indicated.

PLOT #36

ACTUAL GRADUATE QPA FOR STUDENTS IN CATEGORY #2
VERSUS
PREDICTED GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Predicted Graduate QPA = 82 + 3.69 Degree Age + 1.28 GREQ + 0.461 Ugrad
Correlation ACtual QPA vs. Predicted QPA : .354
r squared (predicted to actual): 12.6%

Note is taken of the fact that the observed correlation between actual off-campus grades and predicted on-campus grades (.354) is higher than that indicated when off-campus grades were correlated against their own predictors (.316). Results from the regression analysis offered similar results. When regressed against their own predictors, the *r* squared for off-campus students against their own predictor was 10.0% (8.7% adjusted for degrees of freedom). When off-campus (actual) performance was subjected to regression analysis against the best predictors for students in Category #1, the model resulted in a 12.6% (11.1% adjusted) fit. This is significant to the .01 level. In effect, Category #2 student performance was predicted with more accuracy by the formula established for on-campus graduate students.

This inconsistency results from the larger sample size used to determine the relationships among on-campus students. With a larger sample size, the results from the initial stepwise regression is more reliable. The fact that the stepwise regression for off-campus degree students resulted only in identifying the GRE quantitative test as important, and further that a better fit is exhibited when regressing off-campus students to on-campus models, indicates that with a larger sample size in Category #2, a differing result would have come from its stepwise regression.

In order to determine whether significant differences resulted when actual grades for off-campus Electrical and Computer degree students analyzed against predictors for on-campus students, both were subjected to an analysis of variance. The results from this exercise, noted below, indicated no significant differences.

TABLE #69

ACTUAL PERFORMANCE OF OFF-CAMPUS ECE GRADUATE DEGREE STUDENTS COMPARED TO PREDICTED PERFORMANCE FOR ON CAMPUS ECE GRADUATE STUDENTS

```
           Mean            INDIVIDUAL 95% CI FOR MEAN
           Grad            BASED ON POOLED STDEV
       N   QPA    StDev   ----+---------+---------+---------+--
Act'l  84  3.441   .507               (-----------*-----------)
Prdic  65  3.360   .314     (------------*------------)
                          ----+---------+---------+---------+--
                             3.28      3.36      3.44      3.52
```

F=1.27: Not Significant

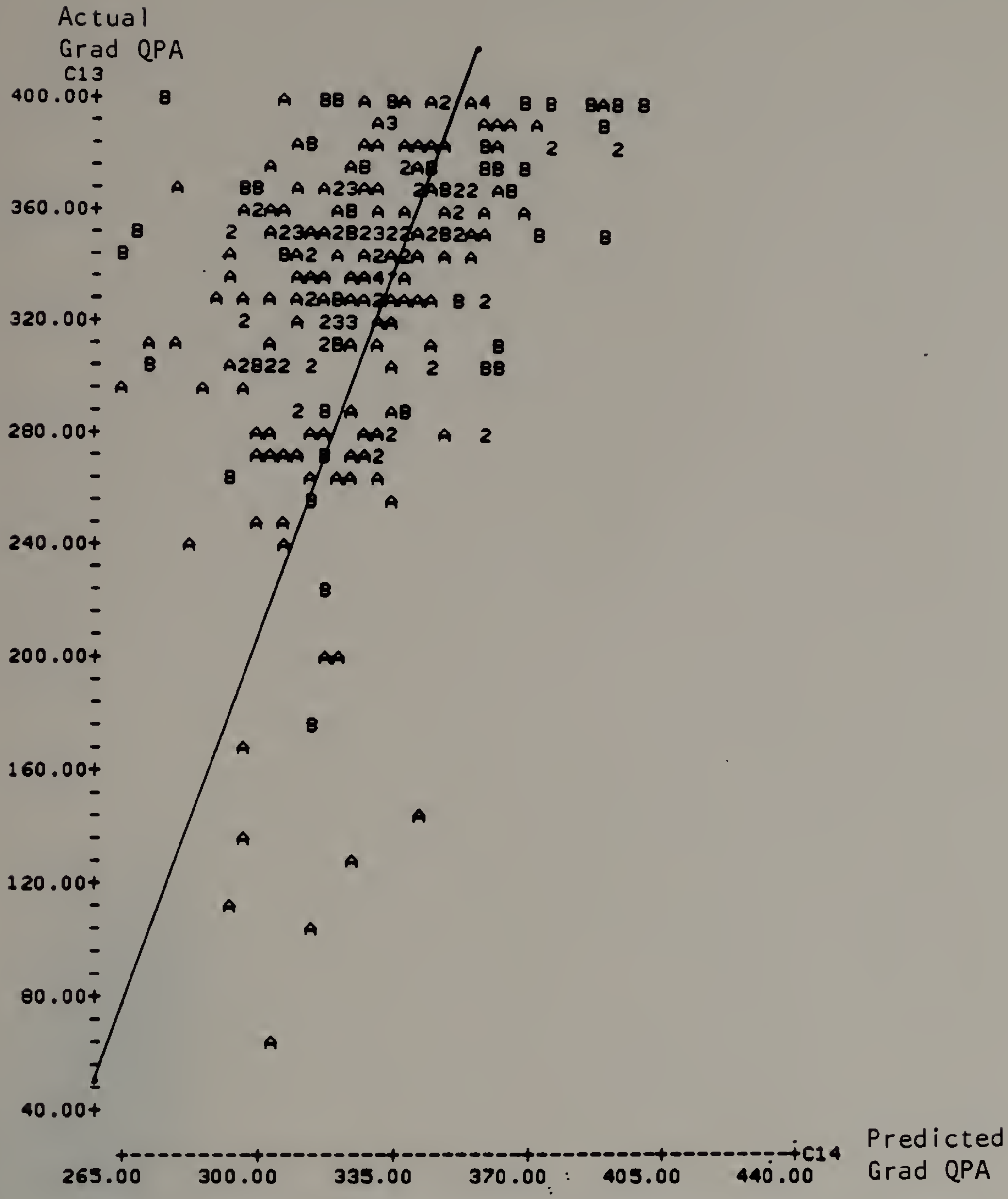
Summary: Variations between actual graduate performance for off-campus ECE degree students is statistically insignificant when compared to predicted graduate quality point average for on-campus ECE graduate students.

With this ANOVA, the hypothesis that off-campus Electrical and Computer Engineering graduate students perform differently than their on-campus colleagues is effectively rejected. It is a further indication that the use of non-tutored videotape instruction does not detract from the effective delivery of quality graduate engineering education.

The following plot offers an additional indication of the closeness in levels of performance among Electrical and Computer Engineering students. The letter A represents the plot of actual versus predicted performance for on-campus students. Off-campus degree students are represented by the letter "B". In this model, the correlation between predicted and actual performance is .394. The regression line predicts 15.5% of the populations (15.2% adjusted for degrees of freedom) and is significant to the .01 level.

PLOT #37

ACTUAL GRADUATE QPA FOR STUDENTS IN CATEGORY #1
AND STUDENTS IN CATEGORY #2 VERSUS
PREDICTED GRADUATE QPA FOR STUDENTS IN CATEGORY #1



Predicted Graduate QPA = 82 + 3.69 Degree Age + 1.28 GREQ + 0.461 Ugrad
Correlation (Actual QPA v. Predicted QPA): .394
r squared (predicted to actual): 15.5%

RELATIONSHIP BETWEEN ACTUAL AND PREDICTED GRADUATE PERFORMANCE BETWEEN AND AMONG ON AND OFF-CAMPUS DEGREE STUDENTS IN INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

> There is no statistically significant relationship between the predicted and actual graduate quality point averages of on-campus students in Industrial Engineering/Operations Research and off-campus video-based Engineering Management graduate students.

The stepwise regression for variables impacting upon on-campus graduate students enrolled in Industrial Engineering/Operations Research courses indicated a set of key variables consisting of chronological age score of the quantitative portion of the Graduate Record Examination. The regression analysis offered the following formula.

$$\text{Predicted Performance} = 268 - [(3.29)(\text{Age})] + [(0.245)(\text{GRE Quantitative})]$$

The following is the comparison noted between actual grades earned by off-campus degree students and the predicted grades determined through the regression.

TABLE #70

MEAN ACTUAL VERSUS MEAN PREDICTED PERFORMANCE
ON-CAMPUS GRADUATE STUDENTS
DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

	Actual Graduate QPA	Predicted Graduate QPA
N	83	81
Mean	3.347	3.352
Median	3.450	3.401
StDev	.603	.292
Max	4.000	3.817
Min	.620	2.228

When an analysis of variance was conducted to determine whether statistically significant differences existed between the actual and predicted values, the resulting "*F*" proved insignificant at 0.00.

TABLE #71

ACTUAL VERSUS PREDICTED GRADUATE PERFORMANCE
ON-CAMPUS DEGREE STUDENTS
DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

```
                Mean
                Grad                  INDIVIDUAL 95% CI FOR MEAN
                                      BASED ON POOLED STDEV
           N    QPA    StDev     ----------+---------+---------+------
Act'l     83  3.347    .603       (---------------*---------------)
Prdic     81  3.352    .292        (---------------*---------------)
                                 ----------+---------+---------+------
                                         3.30      3.36      3.42
```

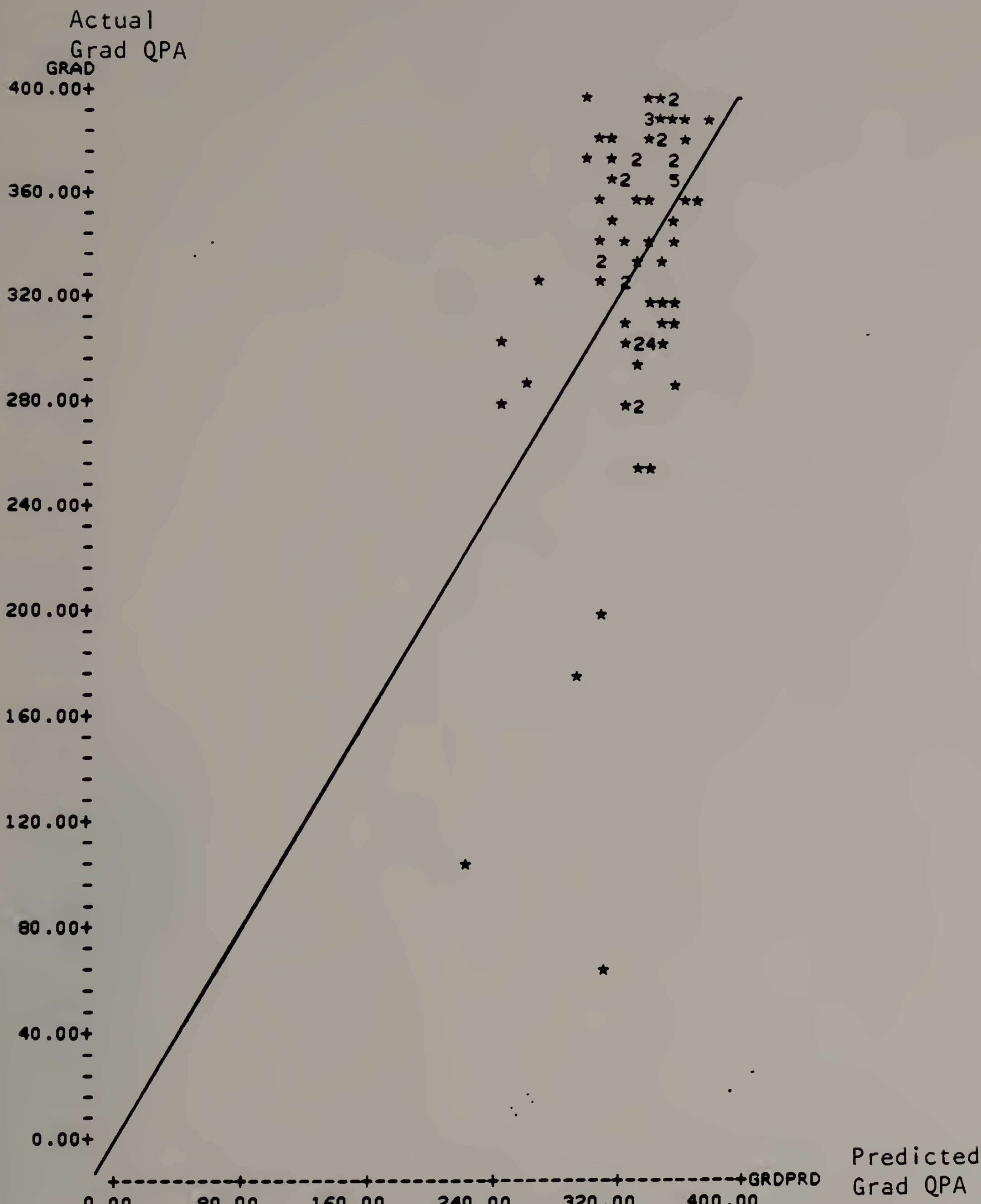
F=0.00: Not Significant

Summary: Statistically significant variations do not exist between actual and predicted levels of graduate performance for on-campus degree students in IEOR.

The following plot describes the interaction of actual versus predicted quality grade point averages for on-campus IEOR graduate students. Note that the correlation between predicted and actual grade point averages for on-campus degree students is .474 and when subjected to regression analysis, predicted 22.5% of the population (21.5% when adjusted for degrees of freedom). The resulting "F", 22.32, is significant to .01.

PLOT #38

ACTUAL GRADUATE QPA FOR STUDENTS IN CATEGORY #4
VERSUS
PREDICTED GRADUATE QPA FOR STUDENTS IN CATEGORY #4



Predicted Graduate QPA = 268 - 3.29 Age + 0.245 GREQ
Correlation (Actual QPA v. Predicted QPA): .474
r squared (Predicted to actual): 22.5%

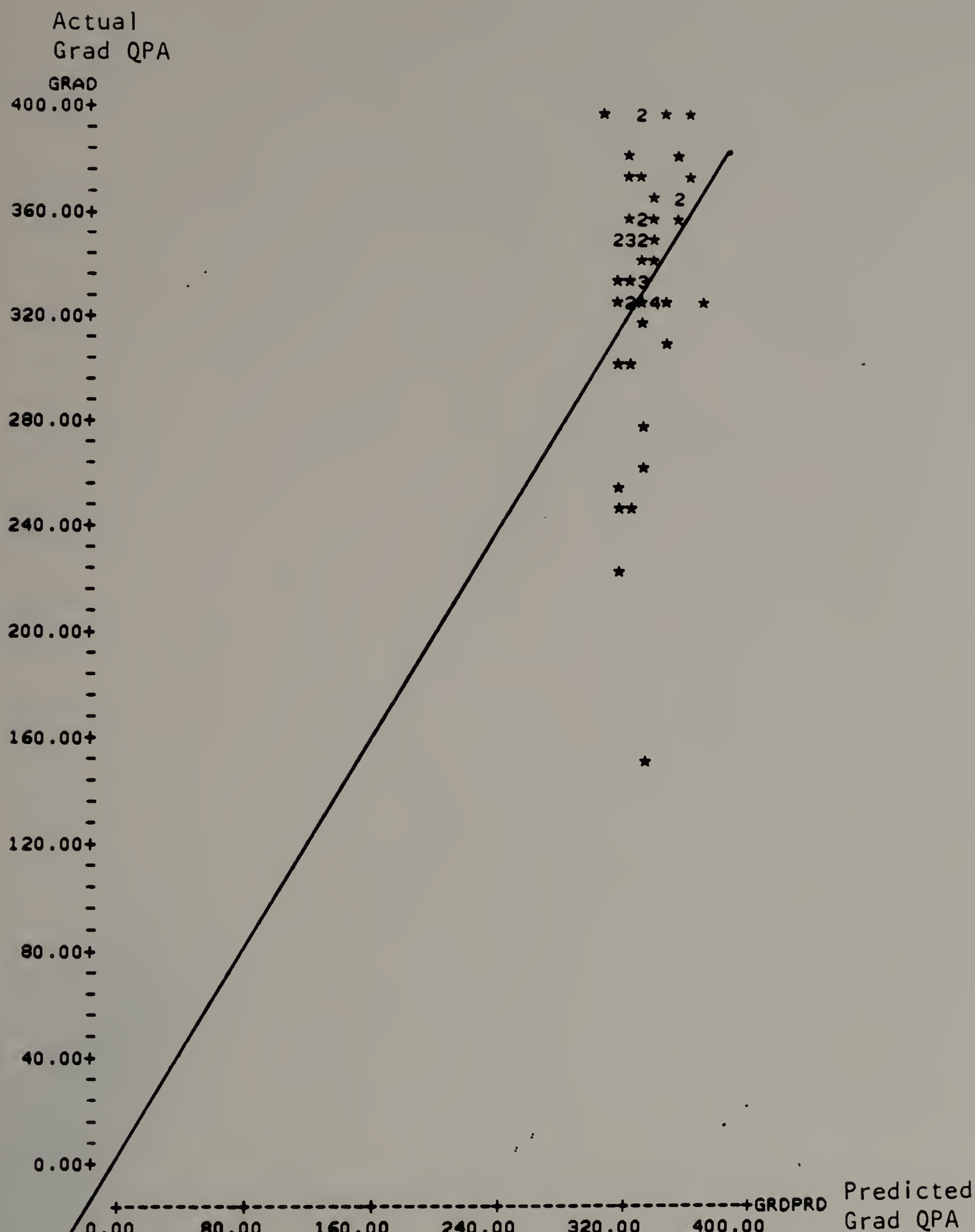
The following plot describes the interaction of actual versus predicted quality grade point averages for off-campus Engineering Management students (Category #5). Its formula results from a stepwise regression indicating the key variable to be student scores on the GRE analytic test.

$$\text{Predicted Performance} = 270 + [(0.132)(\text{GREA})]$$

The correlation between predicted and actual grade point averages for off-campus degree students is .297 and when regressed, predicts 8.8% of the relationship (7.1% when adjusted for degrees of freedom). The resulting "*F*", 5.05, is significant to the .05 level.

PLOT #39

ACTUAL GRADUATE QPA FOR STUDENTS IN CATEGORY #5
VERSUS
PREDICTED GRADUATE QPA FOR STUDENTS IN CATEGORY #5



Predicted Graduate QPA = 270 + 0.132 GREA
Correlation (Actual QPA v. Predicted QPA): .297
r squared (predicted to actual): 8.8%

The following is the comparison noted between actual grades earned by off-campus degree students and the predicted grades determined through the regression for off-campus degree-seeking Engineering Management students.

TABLE #72

OFF-CAMPUS ENGINEERING MANAGEMENT DEGREE STUDENTS
DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

	Actual Graduate QPA	Predicted Graduate QPA
N	66	55
Mean	3.406	3.367
Median	3.500	3.347
StDev	.467	.139
Max	4.000	3.756
Min	1.500	3.122

When an analysis of variance was conducted to determine whether statistically significant differences existed between the actual and predicted values, the resulting "_F_" proved insignificant at 0.35.

TABLE #73

ACTUAL VERSUS PREDICTED GRADUATE PERFORMANCE AMONG OFF-CAMPUS ENGINEERING MANAGEMENT DEGREE STUDENTS

```
             Mean             INDIVIDUAL 95% CI FOR MEAN
             Grad             BASED ON POOLED STDEV
          N  QPA    StDev     -----+---------+---------+---------+-
Act'l    66 3.406   .467              (--------------*-------------
Prdic    55 3.367   .139      (--------------*--------------)
                              -----+---------+---------+---------+-
                                 3.30      3.36      3.42      3.48
0.35:    Not Significant
```

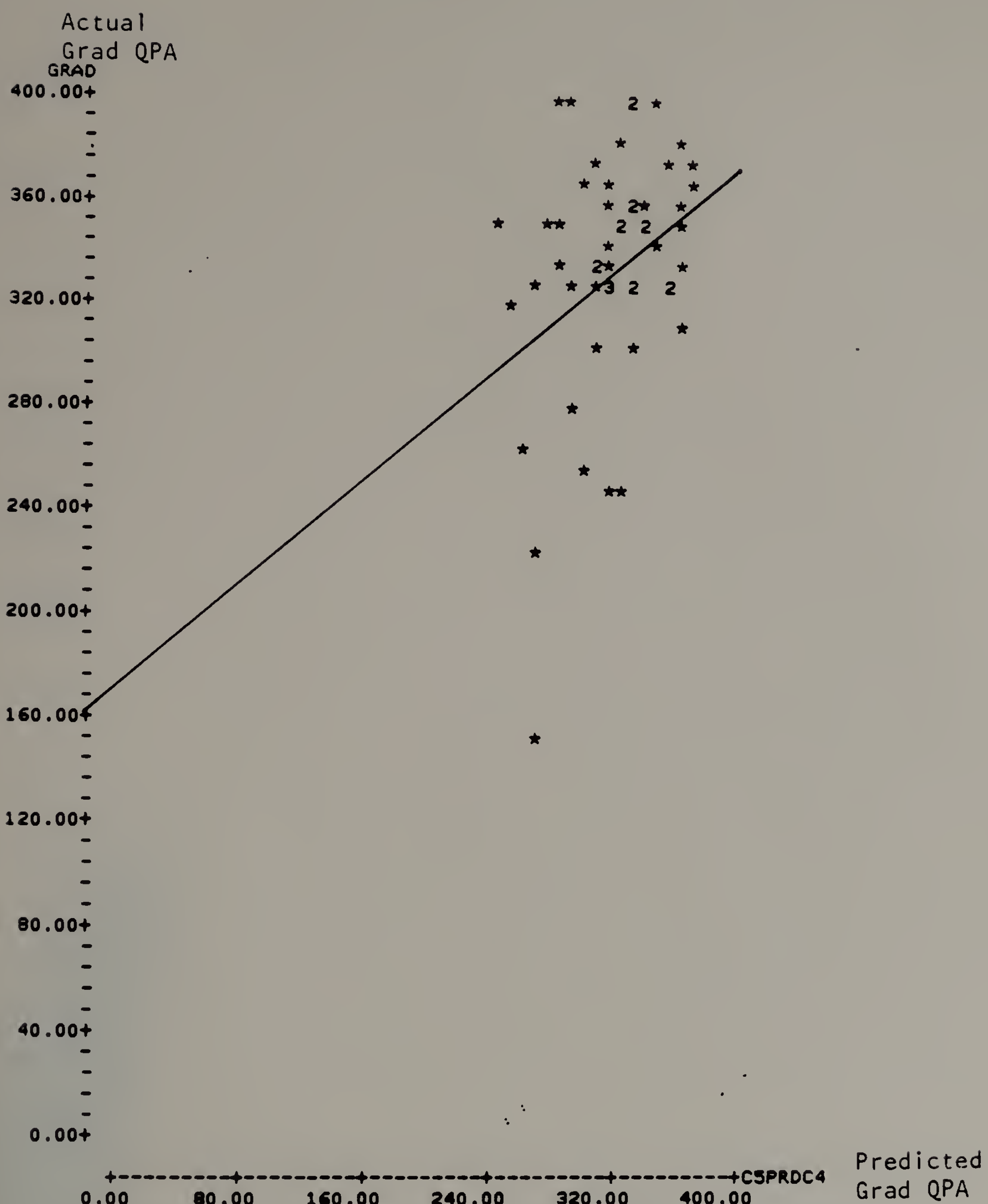
Summary: No statistically significant differences exist between actual and predicted graduate performance among off-campus Engineering Management degree students.

Previously, when off-campus Electrical and Computer Engineering graduate students' performance was compared to on-campus predictors, the analysis of variance recorded no significant difference between predicted and actual quality grade point average. However, when performance of off-campus Engineering Management students was analysed against on-campus predictors, a statistically significant variance was observed.

The following represents the plot of actual Category #5 student performance against the predictors for on-campus grades.

PLOT #40

ACTUAL GRADUATE QPA FOR STUDENTS IN CATEGORY #5
VERSUS
PREDICTED GRADUATE QPA FOR STUDENTS IN CATEGORY #4



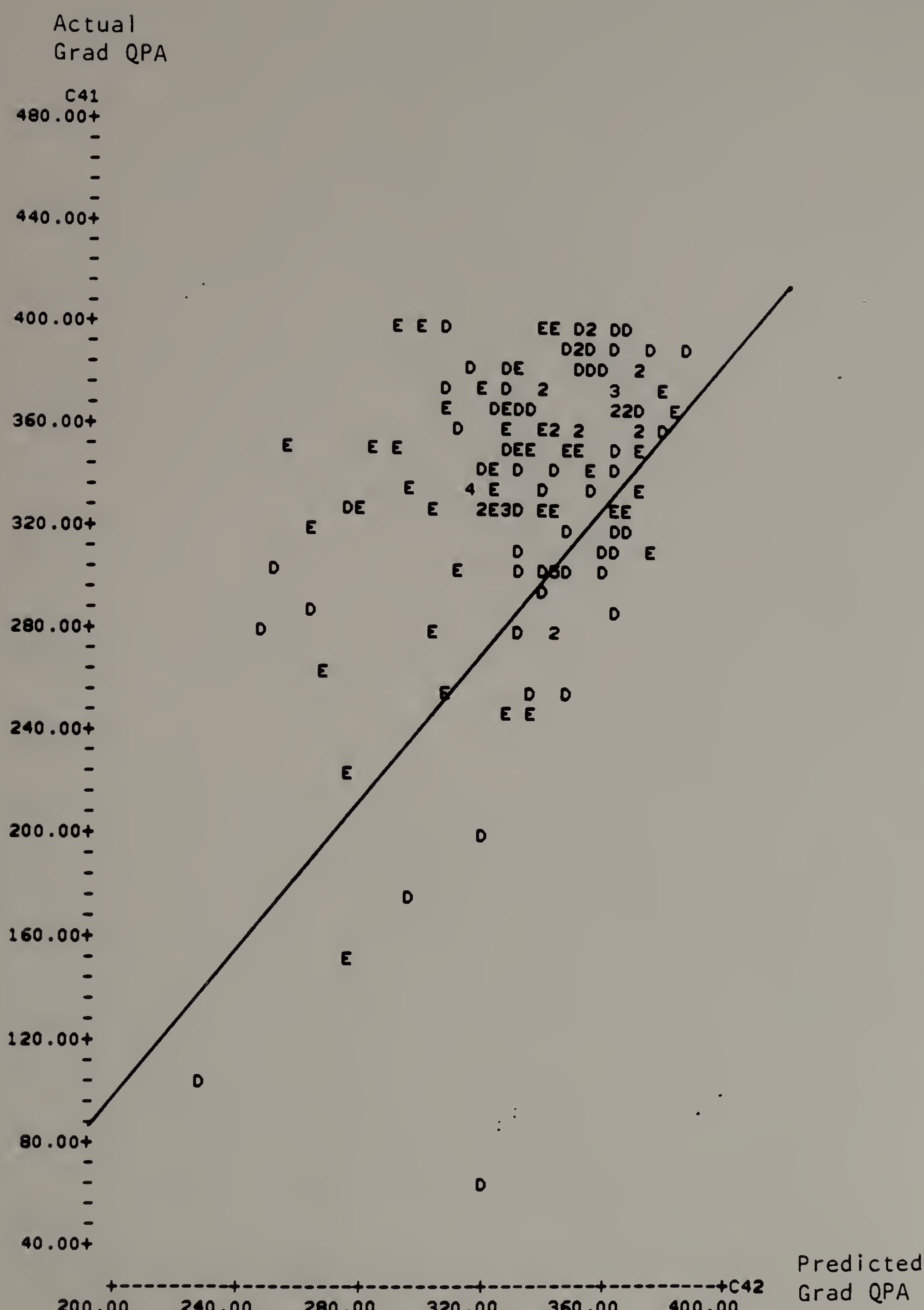
Predicted Graduate QPA = 268 - 3.29 Age + 0.245 GREQ
Correlation (Actual QPA v. Predicted QPA): .365
r squared (Predicted to actual): 13.3%

The statistical correlation between the actual and predicted grades is .365 and when regressed, the relationship accounts for 13.3% (11.7% adjusted for degrees of freedom) of the sample. With an "F" score of 7.99, this is significant to the .01 level.

The following plot depicts actual student grades in both Category #4 and Category #5 against predictors established for on-campus student performance. On-campus performance is reflected by the letter "D" while "E" represents performance of the Engineering Management student population.

PLOT #41

ACTUAL GRADUATE QPA FOR STUDENTS IN CATEGORY #4
AND STUDENTS IN CATEGORY # 5 VERSUS
PREDICTED GRADUATE QPA FOR STUDENTS IN CATEGORY #4



Predicted Graduate QPA = 268 - 3.29 Age + 0.245 GREQ
Correlation (Actual QPA ti Predicted QPA): .365
r squared (predicted to actual): 13.3%

When an analysis of variance is conducted to ascertain significant differences between on-campus IEOR resident graduate students and off-campus Engineering Management students, the result is a "F" score of 5.58. This is indicative of significance to the .05 level.

TABLE #74

COMPARISON OF ACTUAL PERFORMANCE OF OFF-CAMPUS ENGINEERING MANAGEMENT STUDENTS TO ON-CAMPUS IEOR GRADUATE STUDENT PREDICTORS

```
           Mean             INDIVIDUAL 95% CI FOR MEAN
           Grad             BASED ON POOLED STDEV
        N  QPA    StDev     ----------+----------+----------+----
Act'l  66  3.406   .467                      (-------*-------)
Prdic  55  3.230   .318     (--------*--------)
                            ----------+---------+---------+------
                                    3.24      3.36      3.48
F=5.58:  .05 Level
```

Summary: A statistically significant variation exists between actual off-campus student performance and on-campus predicted graduate grade point average.

At first blush, the analysis of variance indicates that there is a significant difference between the actual performance of off-campus students and predicted performance levels established for on-campus IEOR graduate students. It also evidences a trend that off-campus students perform at a higher level. This would refute the contention that no significant differences would occur when comparing actual versus predicted performance. However, a comparison of the Engineering Management curriculum to those courses available to on-campus IEOR graduate students results in calling these assumptions into question. The curriculum available to off-campus Engineering Management graduate students narrow and more structured than that open to on-campus students. While consisting of videotaped courses taught on-campus, there are fewer course options available to off-campus students. This batches the off-campus students into a narrower range of courses than those available for selection by on-campus students and would result in an artificial comparison. This situation is contrary to that in Electrical and Computer Engineering where the range of courses available to the off-campus students is nearly as broad as that available to the on-campus enrollee.

This is not to intimate that the Engineering Management courses are less rigorous than those non-videotaped courses available to and selected by their on-campus colleagues. On the other hand, the curriculum is acknowledged as being less quantitative and students are able to bring much of their work experiences into the classroom. For instance, many courses require student projects or involve students in case study methodology rather than large amounts of quantitative analysis. The former forms of analysis are common to the experience of the working engineering manager. This calls into question the significance of the analysis offered by the ANOVA and its impression that off-campus students perform at a higher level than would be indicated by on-campus predictors.

COMPARISON OF ACTUAL COURSE GRADES BY ON AND OFF-CAMPUS STUDENTS ENROLLED IN THE SAME COURSE

DEPARTMENTS OF ELECTRICAL AND COMPUTER ENGINEERING AND COMPUTER AND INFORMATION SCIENCES

> There is no statistically significant difference in performance, as measured by grades received, between on-campus and off-campus video-based graduate students

enrolled in the same courses offered through the Department of Electrical and Computer Engineering or Computer and Information Sciences.

In order to assess whether students in one category performed at a statistically different level from those in an other, one-way analyses of variance were conducted on 37 course sections offered by the departments of Electrical and Computer Engineering (36 courses) and Computer and Information Sciences (1 course). Course sections were selected for analysis if their enrollment consisted of at least two on-campus and two off-campus degree students participating through the College of Engineering's Videotape Instructional Program.

If course sections met this threshold, off-campus non-degree students were included in the ANOVA. If, in such instances, the resulting "F" score proved significant, a post-hoc test (Scheffe) was initiated to determine whether significant differences in performance existed between students in Category #1 and Category #2. This would effectively remove non-degree students from the analysis and would offer a valid test determining significant performance differences between on and off-campus degree students.

The resulting analyses indicated that throughout the thirty-six course-sections observed, twenty-eight yielded insignificant "_F_" scores. This would indicate that in those course-sections, student category did not significantly account for variation in performance.

Significant "_F_"'s were observed in eight courses offered by the Department of Electrical and Computer Engineering. Of these, three showed statistically significant differences to the .05 level with the balance at the .01 level. In seven of these instances, post-hoc (Scheffe) analyses were conducted to see if, upon removal of the off-campus non-degree students, significant differences were found between students in Category #1 and Category #2. None of these cases offered a significant difference in the performance between on and off-campus degree students.

In the one course offering significant "_F_" score (ECE 687, offered in Fall 1983), registration information indicated that enrollment consisted of fourteen on and two off-campus graduate students. There were no off-campus non-degree (Category #3) students in the course-section.

On-campus degree students had a mean course grade of 2.93 with a standard deviation of .267. Both of the off-campus enrollees earned a grade of "AB" (3.5). The ANOVA resulted in an "*F*" of 8.62 and a confidence level of .05. While these results do offer statistical significance, the low sample size of off-campus degree students reduces the impact of this finding.

Taken as a whole, of the 36 courses subjected to analysis, only one (2.78% of the sample) offered significant differences in performance due to a student's category. As a result, when considering the question whether variance in student performance can be accounted by category, the answer is no.

ANALYSES OF VARIANCE INDICATING CHANGES IN GRADUATE PERFORMANCE BY STUDENT CATEGORY AMONG STUDENTS ENROLLED IN THE SAME COURSES OFFERED BY THE DEPARTMENTS OF COMPUTER AND INFORMATION SCIENCES AND ELECTRICAL AND COMPUTER ENGINEERING

ECE 560
FALL, 1981

```
                               INDIVIDUAL 95% CI FOR MEAN
                               BASED ON POOLED STDEV
         N  MEAN   STDEV  --+---------+---------+---------+----
CAT #1   2  3.75    .354       (------------*------------)
CAT #2   2  4.00      0         (------------*------------)
CAT #3   5  1.60   2.191  (--------*-------)
                          --+---------+---------+---------+----
                            0       2.40      4.80      7.20
```

F .80
LEVEL OF SIGNIFICANCE: NONE

ECE 560
FALL, 1982

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
         N   MEAN   STDEV   -----+---------+---------+---------+-
CAT #1   2   4.00       0     (---------------*---------------
CAT #2   5   3.20   1.789      (----------*----------)
CAT #3  38   1.54   1.940   (---*---)
                            -----+---------+---------+---------+-
                                1.60      3.20      4.80      6.40
F=3.04
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 560
SUMMER, 1983

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
         N   MEAN   STDEV   ----+---------+---------+---------+--
CAT #1   3   3.83    .289          (------------*------------)
CAT #2   3   3.50    .500    (------------*------------)
                            ----+---------+---------+---------+--
                             3.00      3.50      4.00      4.50
F=1.00
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 567
SPRING, 1983

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
         N   MEAN   STDEV   ----------+---------+---------+------
CAT #1   3   3.50    .500       (-----------*-----------)
CAT #2   3   3.17    .764   (-----------*-----------)
                            ----------+---------+---------+------
                                    3.00      3.75      4.50
F=0.60
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 570
SPRING, 1983

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
          N   MEAN   STDEV  --+---------+---------+---------+----
CAT #1    2   4.00       0        (-----------*-----------)
CAT #2    2   3.75    .354     (------------*------------)
CAT #3    1   4.00       0    (----------------*----------------
                            --+---------+---------+---------+----
                            3.00      3.60      4.20      4.80
F=0.60
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 570
FALL, 1984

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
          N   MEAN   STDEV  ----+---------+---------+---------+--
CAT #1   13   2.88    .961        (-----*------)
CAT #2    2   3.25    .354  (----------------*----------------)
CAT #3    4   3.12    .250      (-----------*-----------)
                            ----+---------+---------+---------+--
                              2.25      3.00      3.75      4.50
F=0.24
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 571
FALL, 1981

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
         N   MEAN   STDEV  -------+---------+---------+---------
CAT #1   2   4.00       0         (-------------*--------------
CAT #2   2   3.50    .707      (-------------*---------------)
CAT #3   9   1.67    .159   (-----*------)
                           -------+---------+---------+---------
                               1.60      3.20      4.85
F=2.99
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 584
FALL, 1983

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
         N   MEAN   STDEV  ----+---------+---------+---------+--
CAT #1  22   3.39    .975             (----*-----)
CAT #2   2   3.50    .707  (-----------------*-----------------)
CAT #3   2   3.50    .707  (-----------------*-----------------)
                           ----+---------+---------+---------+--
                            2.40      3.20      4.00      4.80
F=0.02
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 602
SPRING, 1981

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
         N   MEAN   STDEV  ---------+---------+---------+-------
CAT #1   6   3.00   1.517    (----------*----------)
CAT #2   3   3.33    .577   (---------------*--------------)
CAT #3   5   2.80   1.681  (-----------*-----------)
                           ---------+---------+---------+-------
                                 2.40      3.60      4.80
F=0.12
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 602
SPRING, 1984

```
                           INDIVIDUAL 95% CI FOR MEAN
                           BASED ON POOLED STDEV
          N   MEAN   STDEV ------+---------+---------+---------+
CAT #1    5   3.20    .274   (-------------*-------------)
CAT #2    8   3.50    .463              (----------*----------)
CAT #3    6   3.08    .861 (------------*------------)
                           ------+---------+---------+---------+
                               2.80      3.20      3.60      4.00
F=0.94
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 603
FALL, 1984

```
                           INDIVIDUAL 95% CI FOR MEAN
                           BASED ON POOLED STDEV
          N   MEAN   STDEV -------+---------+---------+---------
CAT #1   15   2.93    .651  (--------*---------)
CAT #2    5   3.30    .837    (----------------*----------------
                           -------+---------+---------+---------
                                2.80      3.20      3.60
F=1.04
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 604
FALL, 1983

```
                           INDIVIDUAL 95% CI FOR MEAN
                           BASED ON POOLED STDEV
          N   MEAN   STDEV --+---------+---------+---------+----
CAT #1    5   3.40    .418          (-------*-------)
CAT #2    2   3.50      0        (------------*-----------)
CAT #3    6   2.67    .753 (-------*------)
                           --+---------+---------+---------+----
                           1.20      2.40      3.60      4.80
F=1.27
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 605
SUMMER, 1984

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
         N   MEAN   STDEV  --+---------+---------+---------+----
CAT #1  14   3.07    .475    (------*------)
CAT #2   3   3.33    .577  (--------------*--------------)
                           --+---------+---------+---------+----
                            2.80      3.20      3.60      4.00
F=0.71
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 648
FALL, 1982

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
         N   MEAN   STDEV  -------+---------+---------+---------
CAT #1   5   3.50    .354              (--------*--------)
CAT #2   2   3.00       0      (-------------*--------------)
CAT #3   9   1.44   1.722  (------+------)
                           -------+---------+---------+---------
                                 1.40      2.80      4.20
F=3.96
LEVEL OF SIGNIFICANCE:  .05 (NO SIGNIFICANT DIFFERENCE
BETWEEN CATEGORY 1 AND CATEGORY 2)
```

ECE 660
SUMMER, 1983

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
         N   MEAN   STDEV  ----+---------+---------+---------+--
CAT #1   4   3.75    .500        (------------*------------)
CAT #2   2   3.75    .354   (-----------------*-----------------
                           ----+---------+---------+---------+--
                              3.00      3.50      4.00      4.50
F=0.00
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 660
FALL, 1984

```
                               INDIVIDUAL 95% CI FOR MEAN
                               BASED ON POOLED STDEV
         N   MEAN   STDEV  ------+---------+---------+---------+
CAT #1   5   3.80    .274   (-----------*----------)
CAT #2   2   4.00       0   (-----------------*----------------
CAT #3   6   3.75    .418   (---------*---------)
                           ------+---------+---------+---------+
                               3.60      3.90      4.20      4.50
F=0.40
LEVEL OF SIGNIFICANCE:  NONE
```

ECE 668
FALL, 1979

```
                               INDIVIDUAL 95% CI FOR MEAN
                               BASED ON POOLED STDEV
         N   MEAN   STDEV  -------+---------+---------+---------
CAT #1   6   2.83    .683             (---------*--------)
CAT #2   4   3.25    .866              (-----------*-----------)
CAT #3  16   1.16   1.599   (-----*-----)
                           -------+---------+---------+---------
                                1.20      2.40      3.60
F=5.71
LEVEL OF SIGNIFICANCE:  .01 LEVEL (NO SIGNIFICANT DIFFERENCE
EXISTS IN PERFORMANCE BETWEEN CATEGORY #1 AND CATEGORY #2
STUDENTS)
```

ECE 668
FALL, 1980

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
          N   MEAN   STDEV  -------+---------+---------+---------
CAT #1    8   3.44    .623                        (------*------)
CAT #2    8   3.12    .641                     (------*------)
CAT #3   17   1.03   1.505   (----*---)
                            -------+---------+---------+---------
                                  1.20      2.40      3.60
```

F=15.13
LEVEL OF SIGNIFICANCE: .01 LEVEL (NO SIGNIFICANT DIFFERENCES BETWEEN PERFORMANCE OF STUDENTS IN CATEGORY #1 AND CATEGORY #2)

ECE 668
FALL, 1981

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
          N   MEAN   STDEV  -------+---------+---------+---------
CAT #1    8   3.82    .372    (----------*-----------)
CAT #2    5   4.00       0    (--------------*--------------)
CAT #3   15   3.60   1.039  (--------*--------)
                            -------+---------+---------+---------
                                  3.50      4.00      4.50
```

F=15.13
LEVEL OF SIGNIFICANCE: NONE

ECE 668
FALL, 1982

```
                                   INDIVIDUAL 95% CI FOR MEAN
                                   BASED ON POOLED STDEV
          N   MEAN   STDEV  -+---------+---------+---------+-----
CAT #1    4   3.50    .408         (------------*------------)
CAT #2    6   2.92   1.530       (---------*----------)
CAT #3   18   1.89   1.632   (-----*-----)
                            -+---------+---------+---------+-----
                            1.20      2.40      3.60      4.80
```

F=2.40
LEVEL OF SIGNIFICANCE: NONE

ECE 668
SPRING, 1982

```
                                   INDIVIDUAL 95% CI FOR MEAN
                                   BASED ON POOLED STDEV
          N   MEAN   STDEV  ------+---------+---------+---------+
CAT #1    2   2.00   2.828  (----------------*----------------
CAT #2    4   2.75   1.893             (----------*-------------
CAT #3    7   0.57   1.522  (----------*--------)
                            ------+---------+---------+---------
                                  0       1.60      3.20      4.80
```

F=1.97
LEVEL OF SIGNIFICANCE: NONE

ECE 669
SPRING, 1981

```
                           INDIVIDUAL 95% CI FOR MEAN
                           BASED ON POOLED STDEV
         N  MEAN  STDEV  ---------+---------+---------+-------
CAT #1   4  3.75   .050                         (-----*-----)
CAT #2   6  2.58   .136                    (----*----)
CAT #3   2     0      0   (-------*-------)
                         ---------+---------+---------+-------
                                  0       2.00      4.00
```

F=8.48
LEVEL OF SIGNIFICANCE: .01 LEVEL (NO SIGNIFICANT DIFFERENCES IN PERFORMANCE AMONG STUDENTS IN CATEGORY #1 AND CATEGORY #2)

ECE 669
SPRING, 1982

```
                           INDIVIDUAL 95% CI FOR MEAN
                           BASED ON POOLED STDEV
         N  MEAN  STDEV  -------+---------+---------+---------
CAT #1   8  3.69   .458   (--------*--------)
CAT #2   3  4.00      0         (-------------*---------------
CAT #3   4  4.00      0           (-----------*------------)
                         -------+---------+---------+---------
                              3.60      3.90      4.20
```

F=1.49
LEVEL OF SIGNIFICANCE: NONE

ECE 669
SPRING, 1983

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
         N   MEAN   STDEV  -----+---------+---------+---------+-
CAT #1   3   3.50    .500                          (-------*-------
CAT #2   6   3.33    .561                          (-----*----)
CAT #3   2   2.00       0  (---------*---------)
                           -----+---------+---------+---------+-
                              1.60      2.40      3.20      4.00
```

F=7.01
LEVEL OF SIGNIFICANCE: .05 LEVEL (NO SIGNIFICANT DIFFERENCES IN PERFORMANCE BETWEEN STUDENTS IN CATEGORY #1 AND CATEGORY #2)

ECE 669
SPRING, 1984

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
         N   MEAN   STDEV  ---------+---------+---------+-------
CAT #1   6   3.67    .516   (---------*----------)
CAT #2   5   4.00       0             (----------*-----------)
CAT #3   3   4.00       0        (--------------*--------------
                           ---------+---------+---------+-------
                                  3.60      3.90      4.20
```

F=1.57
LEVEL OF SIGNIFICANCE: NONE

ECE 672
SPRING, 1982

```
                             INDIVIDUAL 95% CI FOR MEAN
                             BASED ON POOLED STDEV
           N   MEAN   STDEV  ---------+---------+---------+------
CAT #1     2   3.75    .354           (-----------*-----------)
CAT #2     5   3.40    .418          (-------*------)
CAT #3     1   3.50       0   (----------------*-----------------
                             ---------+---------+---------+------
                                    3.00      3.60      4.20
```

F=.053
LEVEL OF SIGNIFICANCE: NONE

ECE 673
FALL, 1981

```
                             INDIVIDUAL 95% CI FOR MEAN
                             BASED ON POOLED STDEV
           N   MEAN   STDEV  ---------+---------+---------+------
CAT #1     7   3.56    .476     (----------*----------)
CAT #2     3   3.50    .500  (----------------*---------------)
CAT #3     7   3.07   1.427  (----------*----------)
                             ---------+---------+---------+------
                                    3.00      3.75      4.50
```

F.024
LEVEL OF SIGNIFICANCE: NONE

ECE 673
SPRING, 1983

```
                             INDIVIDUAL 95% CI FOR MEAN
                             BASED ON POOLED STDEV
           N   MEAN   STDEV  ---+---------+---------+---------+---
CAT #1     9   3.28    .712              (----------*----------)
CAT #2     7   2.36   1.676  (-----------*------------)
                             ---+---------+---------+---------+---
                             1.60      2.40      3.20      4.00
```

F=2.23
LEVEL OF SIGNIFICANCE: NONE

ECE 673
SPRING, 1984

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
        N   MEAN   STDEV  ------+---------+---------+---------+
CAT #1  3   3.17    .029                          (----*---)
CAT #2  2   3.50    .071                           (-----*-----
CAT #3  2      0       0  (-----*-----)
                          ------+---------+---------+---------+
                                0       1.40      2.80      4.20
```

$\underline{F}$=47.07
LEVEL OF SIGNIFICANCE: .01 LEVEL (SIGNIFICANT DIFFERENCES IN PERFORMANCE BETWEEN CATEGORY #1 AND CATEGORY #2 WERE NOT EVIDENCED)

ECE 686
SPRING, 1984

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
        N   MEAN   STDEV  -----+---------+---------+---------+-
CAT #1 25   3.38    .362            (--*--)
CAT #2  2   3.75    .354           (-----------*----------)
CAT #3  1   3.50       0  (--------------*--------------)
                          -----+---------+---------+---------+-
                             3.00      3.50      4.00      4.50
```

$\underline{F}$=1.00
LEVEL OF SIGNIFICANCE: NONE

ECE 687
FALL, 1983

```
                                INDIVIDUAL 95% CI FOR MEAN
                                BASED ON POOLED STDEV
        N   MEAN   STDEV  --------+---------+---------+--------
CAT #1 14   2.93    .267  (----*----)
CAT #2  2   3.50       0             (-----------*-----------
                          --------+---------+---------+--------
                                3.00      3.30      4.60
```

$\underline{F}$=8.62
LEVEL OF SIGNIFICANCE: .05 LEVEL

ECE 697
SPRING, 1984

```
                               INDIVIDUAL 95% CI FOR MEAN
                               BASED ON POOLED STDEV
         N   MEAN   STDEV  ---+---------+---------+---------+---
CAT #1   2   3.75    .354    (-----------------*----------------
CAT #2   6   2.58   2.010   (---------*---------)
CAT #3   9   2.22   1.394   (-------*-------)
                           ---+---------+---------+---------+---
                           1.40      2.80      4.20      5.60
F=0.75
LEVEL OF SIGNIFICANCE:      NONE
```

ECE 787
SPRING, 1982

```
                               INDIVIDUAL 95% CI FOR MEAN
                               BASED ON POOLED STDEV
         N   MEAN   STDEV  ---------+---------+---------+-------
CAT #1   4   4.00      0                  (----------*----------
CAT #2   2   3.75    .354   (-------------*--------------)
                           ---------+---------+---------+-------
                                 3.60      3.84      4.08
F=2.67
LEVEL OF SIGNIFICANCE:      NONE
```

ECE 791
FALL, 1981

```
                          INDIVIDUAL 95% CI FOR MEAN
                          BASED ON POOLED STDEV
        N   MEAN   STDEV  ----+---------+---------+---------+--
CAT #1  3   2.50   2.179           (---------*--------)
CAT #2  4   3.75    .289                   (-------*---------
CAT #3  9   0.39   1.167   (----*-----)
                          ----+---------+---------+---------+--
                              0       1.60      3.20      4.80
```

F=10.74
LEVEL OF SIGNIFICANCE: .01 LEVEL (NO SIGNIFICANT DIFFERENCES IN PERFORMANCE BETWEEN STUDENTS IN CATEGORY #1 AND CATEGORY #2)

ECE 791
FALL, 1983

```
                          INDIVIDUAL 95% CI FOR MEAN
                          BASED ON POOLED STDEV
        N   MEAN   STDEV  -------+---------+---------+---------
CAT #1  4   2.37   1.797  (----------------*---------------)
CAT #2  8   2.94    .863             (-----------*----------)
CAT #3 11   2.27   1.272       (---------*---------)
                          -------+---------+---------+---------
                               1.60      2.40      3.20
```

F=0.69
LEVEL OF SIGNIFICANCE: NONE

COINS 357
SPRING, 1983

```
                                 INDIVIDUAL 95% CI FOR MEAN
                                 BASED ON POOLED STDEV
          N   MEAN   STDEV  -------+---------+---------+---------
CAT #1    3   3.00   1.000    (--------------*--------------)
CAT #2   12   3.04   1.076           (-------*-------)
CAT #3    8   2.25   1.512  (---------*---------)
                            -------+---------+---------+---------
                                  2.00      3.00      4.00
F=0.69
LEVEL OF SIGNIFICANCE:  NONE
```

COMPARISON OF ACTUAL COURSE GRADES BY ON AND OFF-CAMPUS STUDENTS ENROLLED IN THE SAME COURSE

DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

> There is no statistically significant difference in performance, as measured by grades received, between on-campus and off-campus video-based graduate students enrolled in the same courses offered through the Department Industrial Engineering/Operations Research.

The following data should be viewed in the same light as that presented in the discussion concerning performance in courses offered by the departments of Computer and Information Sciences and Electrical and Computer Engineering. Selection of course-sections and enrollment patterns are subject to the same limitations and similar constraints on sample sizes within categories.

A total of 16 courses offered by the Department of Industrial Engineering/Operations Research met the stated criteria. In nine of the sixteen, student category was not found to be a significant variable. The remaining courses whose ANOVA's did yield a significant "F" score, were subjected to Scheffe post-hoc analyses. In none of these instances did the analyses indicate statistically significant differences in graduate performance between students in Category #4 (on-campus IEOR graduate students) and Category #5 (off-campus degree-seeking Engineering Management students).

The following data evidence a clear statement that in courses offered through the Department of Industrial Engineering/Operations Research, there is no significant variation in grades that results from a student studying on-campus in the resident graduate program or off-campus in a non-tutored videotape delivery system.

ANALYSES OF VARIANCE INDICATING CHANGES IN GRADUATE PERFORMANCE BY STUDENT CATEGORY AMONG STUDENTS ENROLLED IN THE SAME COURSES OFFERED BY THE DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

IEOR 520
FALL, 1982

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
          N  MEAN   STDEV  ----+---------+---------+---------+--
CAT #4    2  3.00   1.414        (------------*------------)
CAT #5   17  3.71    .398                      (----*---)
CAT #6    8  1.25   1.367   (--*---)
                           ----+---------+---------+---------+--
                              1.20      2.40      3.60      4.80
```

F=25.69
LEVEL OF SIGNIFICANCE: .01 LEVEL (SIGNIFICANT DIFFERENCES ARE NOT EXHIBITED IN THE PERFORMANCES OF STUDENTS IN CATEGORY #4 AND CATEGORY #5)

IEOR 520
SUMMER, 1983

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
          N  MEAN   STDEV  --+---------+---------+---------+----
CAT #4    2  3.00    .707  (---------------*---------------)
CAT #5    4  3.75    .289            (----------*------------)
CAT #6    4  2.50   1.732  (-----------*----------)
                           ----+---------+---------+---------+--
                              1.20      2.40      3.60      4.80
```

F=1.13
LEVEL OF SIGNIFICANCE: NONE

IEOR 520
FALL, 1984

```
                                 INDIVIDUAL 95% CI FOR MEAN
                                 BASED ON POOLED STDEV
          N   MEAN   STDEV   ---------+---------+---------+-------
CAT #4    3   3.00   1.000    (----------------*----------------
CAT #5    7   3.36    .556               (-----------*-----------)
CAT #6   22   2.98   1.305               (------*-----)
                             ---------+---------+---------+-------
                                     2.25      3.00      3.75
F=0.29
LEVEL OF SIGNIFICANCE:  NONE
```

IEOR 535
FALL, 1982

```
                                 INDIVIDUAL 95% CI FOR MEAN
                                 BASED ON POOLED STDEV
          N   MEAN   STDEV   ---------+---------+---------+-------
CAT #4    6   3.75    .418                  (------*-----)
CAT #5    2   3.25    .354    (-----------*-----------)
CAT #6    1   3.50       0    (---------------*---------------)
                             ---------+---------+---------+-------
                                     3.00      3.60      4.25
F=1.17
LEVEL OF SIGNIFICANCE:  NONE
```

IEOR 587
FALL, 1982

```
                                 INDIVIDUAL 95% CI FOR MEAN
                                 BASED ON POOLED STDEV
           N   MEAN   STDEV  -----+---------+---------+---------+
CAT #4     4   3.75    .500            (------------*------------
CAT #5    18   3.64    .509                 (-----*-----)
CAT #6    31   1.93   1.574   (---*----)
                             -----+---------+---------+---------+
                                2.00      3.00      4.00      5.00
```

F=12.03
LEVEL OF SIGNIFICANCE: .01 LEVEL (SIGNIFICANT DIFFERENCES DO NOT EXIST IN PERFORMANCE BETWEEN STUDENTS IN CATEGORY #4 AND CATEGORY #5)

IEOR 587
FALL, 1983

```
                                 INDIVIDUAL 95% CI FOR MEAN
                                 BASED ON POOLED STDEV
           N   MEAN   STDEV  -------+---------+---------+---------
CAT #4     5   3.70    .274      (---------------*---------------)
CAT #5    10   3.55    .284      (-----------*----------)
CAT #6    18   3.28    .895   (-------*-------)
                             -------+---------+---------+---------
                                  3.20      3.60      4.00
```

F=0.95
LEVEL OF SIGNIFICANCE: NONE

IEOR 587
SUMMER, 1983

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
           N   MEAN   STDEV  ------+---------+---------+---------+
CAT #4     2   4.00       0        (-----------*------------)
CAT #5     2   3.50    .707 (------------*-----------)
CAT #6     6   3.58    .585         (------*------)
                             ------+---------+---------+---------+
                                 3.00      3.75      4.50      5.25
F=0.50
LEVEL OF SIGNIFICANCE:   NONE
```

IEOR 587
SPRING, 1984

```
                              INDIVIDUAL 95% CI FOR MEAN
                              BASED ON POOLED STDEV
           N   MEAN   STDEV  -----+---------+---------+---------+-
CAT #4     2   3.25    .354     (-------------*--------------)
CAT #5     6   3.25    .758           (-------*--------)
CAT #6    24   1.42   1.530   (---*---)
                             -----+---------+---------+---------+-
                                1.40      2.80      4.20      5.60
F=5.15
LEVEL OF SIGNIFICANCE:  .05 LEVEL (NO SIGNIFICANT
DIFFERENCES IN PERFORMANCE BETWEEN STUDENTS IN CATEGORY #4
AND CATEGORY #5)
```

```
                              IEOR 590
                             FALL, 1983

                             INDIVIDUAL 95% CI FOR MEAN
                             BASED ON POOLED STDEV
          N    MEAN    STDEV -------+---------+---------+---------
CAT #4    3    2.33    2.021        (-------------*--------------
CAT #5    8    2.69    1.710               (--------*--------)
CAT #6    3    1.33    2.309 (--------------*--------------)
                             -------+---------+---------+---------
                                    0        1.60      3.20
F=0.56
LEVEL OF SIGNIFICANCE:  NONE
```

```
                              IEOR 590
                            SPRING, 1983

                             INDIVIDUAL 95% CI FOR MEAN
                             BASED ON POOLED STDEV
          N    MEAN    STDEV -------+---------+---------+---------
CAT #4    3    3.83     .289            (-----------*-----------)
CAT #5    2    3.50        0 (--------------*--------------)
CAT #6    4    3.50     .408     (----------*---------)
                             -------+---------+---------+---------
                                   3.20      3.60      4.00
F=1.00
LEVEL OF SIGNIFICANCE:  NONE
```

```
                              IEOR 654
                            SPRING, 1983

                             INDIVIDUAL 95% CI FOR MEAN
                             BASED ON POOLED STDEV
          N    MEAN    STDEV --+---------+---------+---------+----
CAT #4    8    3.00    1.254            (---------*---------)
CAT #5   15    3.43     .594                    (-------*-------)
CAT #6    7    2.21    1.577 (-----------*----------)
                             --+---------+---------+---------+----
                            1.50       2.25      3.00      3.75
F=3.11
LEVEL OF SIGNIFICANCE:  NONE
```

IEOR 654
SPRING, 1984

```
                          INDIVIDUAL 95% CI FOR MEAN
                          BASED ON POOLED STDEV
         N   MEAN   STDEV -------+---------+---------+---------
CAT #4   7   3.93    .189           (----------*-----------)
CAT #5  18   3.61    .366          (------*------)
CAT #6  22   2.98   1.277 (------*-----)
                          -------+---------+---------+---------
                               3.00      3.60      4.20
```

F=3.97
LEVEL OF SIGNIFICANCE: .05 LEVEL (NO SIGNIFICANT DIFFERENCES EXIST IN THE PERFORMANCE OF STUDENTS IN CATEGORY #4 AND CATEGORY #5)

IEOR 657
SPRING, 1982

```
                          INDIVIDUAL 95% CI FOR MEAN
                          BASED ON POOLED STDEV
         N   MEAN   STDEV ---+---------+---------+---------+---
CAT #4   2   3.50    .071                  (--------*--------
CAT #5   2   3.50    .071                  (--------*--------
CAT #6   1      0       0 (------------*------------)
                          ---+---------+---------+---------+---
                         -2.40         0       2.40      4.80
```

F=9.80
LEVEL OF SIGNIFICANCE: .05 LEVEL (NO SIGNIFICANT DIFFERENCES IN PERFORMANCE BETWEEN STUDENTS IN CATEGORY #1 AND CATEGORY #2)

IEOR 686
FALL, 1983

```
                                  INDIVIDUAL 95% CI FOR MEAN
                                  BASED ON POOLED STDEV
           N   MEAN   STDEV  -------*---------*---------*---------
CAT #4    15   3.77    .026                                  (--*--
CAT #5    12   3.46    .112                                (--*--)
CAT #6     3      0       0   (-----*-----)
                             -------+---------+---------+---------
                                    0       1.40      2.80
```

F=33.33
LEVEL OF SIGNIFICANCE: .01 LEVEL (NO SIGNIFICANT DIFFERENCES IN PERFORMANCE BETWEEN STUDENTS IN CATEGORY #1 AND CATEGORY #2)

IEOR 686
FALL, 1984

```
                                  INDIVIDUAL 95% CI FOR MEAN
                                  BASED ON POOLED STDEV
           N   MEAN   STDEV  -+---------+---------+---------+-----
CAT #4     7   3.86    .378                         (---*--)
CAT #5    14   3.54    .536                       (-*--)
CAT #6     1   2.00       0   (---------*---------)
                             -+---------+---------+---------+-----
                            1.00      2.00      3.00      4.00
```

F=33.33
LEVEL OF SIGNIFICANCE: .01 LEVEL (NO SIGNIFICANT DIFFERENCES IN PERFORMANCE BETWEEN STUDENTS IN CATEGORY #1 AND CATEGORY #2)

IEOR 690
FALL, 1984

```
                                  INDIVIDUAL 95% CI FOR MEAN
                                  BASED ON POOLED STDEV
          N   MEAN    STDEV   ----+---------+---------+---------+--
CAT #4    4   3.25     .289       (----------*-----------)
CAT #5    6   3.50     .447               (---------*--------)
CAT #6    4   3.12     .479    (----------*-----------)
                              ----+---------+---------+---------+--
                                 2.80      3.20      3.60      4.00
F=1.04
LEVEL OF SIGNIFICANCE:   NONE
```

CHAPTER #5

SUMMARY OF THE RESEARCH

CONCLUSIONS

This research was undertaken to accomplish three tasks, the first being to describe on and off-campus video-based graduate engineering students using traditional and accepted quantitative variables. Secondly, efforts were undertaken to determine if off-campus graduate students performed at variance to norms established by on-campus samples. Finally, on and off-campus graduate performance in the same course were measured to ascertain if significant differences could be found between the two samples.

The on-campus sample included students graduating from American institutions of higher education enrolled in the University of Massachusetts' Departments of Electrical and Computer Engineering and Industrial Engineering/Operations Research. Off-campus degree and non-degree graduate students enrolled in these departments' courses made available in a non-tutored videotape mode through the Office of Extended Engineering Education. Students selected were enrolled in the College of Engineering from the Fall 1980 through Spring 1985 academic semesters.

Deleted from the study were those who withdrew from courses without having earned grades. For instance, if a student enrolled in and failed all courses, the record was included for study and given a graduate average of "0". However, if the individual registered but withdrew passing from each of the three courses, no quality point average was indicated. This person was deleted from the data base.

Results provide comprehensive data sets allowing interested individuals the ability to identify and counsel those individuals whose particular characteristics best indicate potential for success in off-campus video-based graduate engineering programs.

The data also validated non-tutored videotaped instruction as an effective delivery tool for the dissemination of graduate engineering courses to small pockets of learners in many and varied disperate locations.

RESEARCH SUMMARY

RELATIONSHIP OF THE VARIABLES TO STUDENT SAMPLES

Relationship of the Variables to Total Student Sample

Review of the data indicate that the selected variables (age and degree age, GRE Verbal, Quantitative, and Analytic scores, and undergraduate quality point average) acting neither singularly nor in concert, offer substantial impact upon performance for the combined sample sample. Students in the sample share the following (mean) characteristics:

Age-29; Degree Age-3.7; GREV-510; GREQ-665; GREA-527; Undergraduate QPA-3.11; Graduate QPA-3.25.

Stepwise regression resulted in an r square of only 7.47% (.01 level of significance) and identified key actors including GRE Verbal and Quantitative tests (Predicted Graduate QPA = 224 + 0.0438 GREV + 0.132 GREQ).

Low predictive values clearly result from the heterogeneity of the sample which includes all students regardless of discipline and mode of instruction and from graduate grade compression at upper levels. Regardless of these realities, it is obvious that outside factors are working to effect variation in graduate performance.

When individual variables are subjected to analysis against the gross sample, age (r square = 0) and degree age (r square = 0) are shown to offer no predictive value. When these variables are grouped into levels, analysis of variance for age shows no main effect on performance. On the other hand, the ANOVA for degree age did reject (to the .01 level) the hypothesis claiming that differences in degree age do not yield variation in performance.

In no instance do age or degree age subgroups offer significant predictors for graduate performance.

Though significant to the .01 level, r squares for GREV, GREQ, and GREA, as well as undergraduate quality point average are low (3.4%, 5.7%, 4.0%, and 2.6%). In all four instances, analyses of variance reject the hypotheses, to the .01 level, that variations within these independent variables do not result in performance differences.

When GRE test scores and undergraduate quality point average are grouped, in only two instances are significant (but still low) predictive relationships found to exist with performance. GREQ above 701 are predict 3.3% of the sample's performance. An undergraduate average above 3.50 on a 4-point scale predicts 5.4%.

A table of statistically significant activities follows:

TABLE #75

SUMMARY OF STATISTICALLY SIGNIFICANT RELATIONSHIPS BETWEEN THE INDEPENDENT VARIABLES AND GRADUATE PERFORMANCE OF THE TOTAL STUDENTS SAMPLE

FACTOR	CORRELATION TO PERFORMANCE	r SQUARED	r SQUARED CORREC. FOR DEG OF FREED.	SIGNFCNCE
Degree				
Age				
All	.119	1.4%	1.2%	.05 Level
GREV				

All	.185	3.4%	3.2%	.01 Level
GREQ				
All	.240	5.7%	5.5%	.01 Level
701+	.180	3.3%	2.6%	.05 Level
GREV				
All	.200	4.0%	3.7%	.01 Level
Ugrad QPA				
All	.160	2.6%	2.3%	.01 Level
3.51/4.00	.232	5.4%	4.1%	.05 Level
Stepwise R				
GREV+GREQ	.257	7.5%		.01 Level

SUMMARY OF INTERACTIONS
INDEPENDENT VARIABLES AGAINST TOTAL STUDENT SAMPLE

Age is not a statistically significant variable accounting for variation in the sample's graduate performance. Age provides little predictive value and correlated poorly to performance.

Although correlation to performance is low, the hypothesis that variation in degree age is not related to variation in graduate performance is rejected. As an overall predictor, degree age is significant but inconsequential. No subgroup is a significant predictor of performance.

The GRE Verbal is a significant but minor predictor of graduate performance. No GREV subgroup is a statistically significant predictor. Analysis of variance rejects rejects the hypothesis (.01 level) that variation in GREV score does not impact on performance. Trends indicate that as mean GREV scores increase, a parallel increase in mean performance occurs.

The GRE Quantitative test is a generally significant (.01) but minimal (3.4%) predictor of graduate performance. Scores above 700 on the GREQ offer significant (.05) but marginal

(3.3%) predictive power. The analysis of variance finds a main effect (.01) between performance and the GREQ. Trends indicate that as mean GREQ scores increase, a parallel increase in performance is realized.

The GRE Analytic test is a generally significant (.01) but minor (4.0%) predictor of graduate performance. Analysis of variance reject the null-hypothesis (.01 level) and finds a mean effect between GREA and graduate performance. Post-hoc analyses indicate significant differences in performance between those scoring 501-600 from those scoring 601-700 on the GREA. No GREA subgroup is a significant predictor of performance.

The undergraduate QPA is a generally significant (.01) but minor predictor (2.6%) of graduate performance. Analysis of variance rejects the hypothesis (.01 level) that variation in Ugrad QPA does not impact on performance. Post-hoc analyses indicate significant differences in performance between those with Ugrad QPA's from 2.51-3.00 and 3.01-3.50. The 3.51-4.00 Ugrad QPA subgroup is a low (4.1%) but significant (.05 level) predictor of performance. Trends indicate that as Ugrad QPA increases from 2.51 to 4.00, a parallel increase occurs in graduate performance.

Relationship of On to Off-Campus Video-Based Graduate Students in the Department of Electrical and Computer Engineering

In five out of seven instances, analyses of variance reject hypotheses claiming no statistically significant differences between on and off-campus video-based students enrolled in courses offered by the Department of Electrical and Computer Engineering. Variables measured included graduate performance, age and degree age, GREV scores, and undergraduate quality point average. Similar hypotheses for the GRE Quantitative and Analytic tests were not be rejected by their ANOVAs.

Off-campus degree students have higher mean graduate quality point averages than both on-campus degree and off-campus non-degree students. They also exhibit a higher mean score on the GREV. On-campus students are generally younger in age and degree age than off-campus video students and have a higher mean undergraduate quality point average. Only a 2 point mean difference existed between the on and off-campus ECE degree students on the GREQ. On-campus students (insignificantly) outscored off-campus students on the GREA by 24 points.

Note the following statistical summary.

TABLE #76

MEAN VALUES OF VARIABLES
ON-CAMPUS VERSUS OFF-CAMPUS STUDENTS
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

CATEGORY	GRAD	AGE	DEGREE AGE	GREV	GREQ	GREA	UGRAD
On-Campus Degree	3.25	25.3	2.2	512	683	583	3.21
Off-Campus Degree	3.44	30.7	6.8	557	681	607	3.10
Off-Campus Non-Degree	3.21	29.5					
HYPOTH REJCTN	Yes .05	Yes .01	Yes .01	Yes .01	No	No	Yes .05

The data allows the following conclusions to be drawn when comparing on and off-campus students enrolled in electrical and computer engineering courses.

The hypothesis asserting that variation in graduate performance cannot be accounted for by student category is significantly (.05) rejected. When the hypothesis is subjected to post-hoc analysis for the removal of off-campus non-degree students, no significant difference in performance is found between on and off-campus degree students. Trends exhibit a higher mean performance among off-campus degree students than on-campus. Off-campus non-degree students exhibit the lowest mean graduate quality point average.

The hypothesis suggesting no significant differences in age between on and off-campus students is rejected (.01). Off-campus students are generally older than on-campus students and there is a negligible difference in age between off-campus degree and non-degree students.

The hypothesis suggesting no significant differences in degree ages between on and off-campus degree students is rejected (.01). Off-campus students have a mean degree age older than that for on-campus students.

The hypothesis asserting no statistically significant differences between on and off-campus degree students on the GREV is rejected (.01). Off-campus degree students have a higher mean score on the GREV than do on-campus students.

No main effect is found between categories for the GREQ.

No main effect is found between categories for the GREA.

The hypothesis asserting no statistically significant differences between on and off-campus degree students for undergraduate quality point average is rejected (.05). On-campus degree students exhibit a higher mean undergraduate average than to off-campus students.

Relationship of On to Off-Campus Video-Based Graduate Students in the Department of Industrial Operations Research

In four out of seven instances, analyses of variance reject hypotheses claiming no statistically significant differences between on and off-campus video-based students enrolled in courses offered by the Department of Industrial Engineering/Operations Research. Variables measured included graduate performance, age and degree age, and undergraduate quality point average. Main effects between student categories were found for GRE Verbal, Quantitative, and Analytic tests

Similar to the results exhibited by ECE students, off-campus IEOR degree students showed higher mean graduate quality point averages than both on-campus degree and off-campus non-degree students. On-campus degree students performed better than off-campus non-degree students. Off-campus students scored (with statistical insignificance) higher on the GRE verbal and quantitative tests. On-campus students offered a higher mean undergraduate quality point average and a higher mean score on the GRE Analytic test and are generally younger in chronological and degree age.

Note the following statistical summary.

TABLE #77

MEAN VALUES OF VARIABLES
ON-CAMPUS VERSUS OFF-CAMPUS STUDENTS
DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

MEAN VALUES

CATEGORY	GRAD	AGE	DEGREE AGE	GREV	GREQ	GREA	UGRAD
On-Campus Degree	3.35	26.2	3.2	468	627	545	3.06
Off-Campus Degree	3.41	31.3	5.1	505	640	537	2.75
Off-Campus Non-Degree	3.06	30.6					
HYPOTH REJCTN	Yes .01	Yes .01	No	No	No	No	Yes .01

The data supports the following summary conclusions.

The hypothesis suggesting no significant differences in graduate performance between on and off-campus students is rejected (.01). However, post-hoc analysis indicates no statistically significant variation in graduate quality point average between on and off-campus degree students. Mean graduate performance by off-campus degree students exceeds that of on-campus degree students. Off-campus non-degree students illustrate the lowest mean level of performance.

The hypothesis asserting no significant differences in age between on and off-campus students is rejected (.01). While off-campus students are generally older than on-campus students, there is no significant difference in age between off-campus degree and non-degree students.

The hypothesis asserting no significant difference in degree age between on and off-campus degree students is rejected (.05). The mean degree age of off-campus students is higher than that for on-campus students.

Scores on the GREV for on-campus students are not significantly at variance from those of off-campus students. Off-campus students have a higher mean GREV than do on-campus students.

Scores on the GREQ for on-campus students are not significantly at variance from those of off-campus students. Off-campus students have a higher mean GREQ than do on-campus students.

Scores on the GREA for on-campus students are not significantly at variance from those of off-campus students. On-campus students have a higher mean GREQ than do off-campus students.

The hypothesis suggesting no significant variations between on and off-campus students for the undergraduate quality point average is rejected (.01). On-campus student have a higher mean undergraduate quality point average than do off-campus students.

RELATIONSHIP OF THE INDEPENDENT VARIABLES BY STUDENT CATEGORY

To further the refine the analyses, students were divided by academic discipline and then subdivided by program. A total of six categories were created including:

TABLE #78

SUMMARY OF STUDENT CATEGORIES

On-campus degree students: Department of Electrical and Computer Engineering (CATEGORY #1)

Off-campus video-based degree students: Department of Electrical and Computer Engineering (CATEGORY #2)

Off-campus non-degree video-based degree students enrolled in courses offered by the Department of Electrical and Computer Engineering (CATEGORY #3)

On-campus degree students: Department of Industrial Engineering/Operations Research (CATEGORY #4)

Off-campus video-based degree students: Engineering Management concentration, Department of Industrial Engineering/Operations Research (CATEGORY #5)

Off-campus video-based non-degree students enrolled in courses offered by the Department of Industrial Engineering/Operations Research (CATEGORY #6)

The following is a summary of the data reflecting variables' mean values and correlations to each of the student categories. Note should be taken of the fact that available data for off-campus non-degree students (Categories #3 and #6) was limited to graduate performance and student age.

TABLE #79

SUMMARY OF
CORRELATIONS AND MEANS BY CATEGORY

	CAT 1	CAT 2	CAT 3	CAT 4	CAT 5	CAT 6
MEAN GRADUATE QUALITY POINT AVERAGE:	3.25	3.44	3.21	3.34	3.41	3.06
AGE:						
Sample Size	219	86	424	85	66	152
Mean	25.3	30.7	30.5	26.2	31.3	31.1
Corr. to Grad QPA	.161	.102	.054	-.338	-.122	.052
DEGREE AGE:						
Sample Size	228	87		85	67	
Mean	2.23	6.78		3.28	5.10	
Corr. to Grad QPA	.226	.130		-.307	.105	
GRE VERBAL:						
Sample Size	208	73		81	55	
Mean	512	557		468	505	
Corr. to Grad QPA	.182	.316		.366	.303	

GRE QUANTITATIVE:				
Sample Size	203	73	81	55
Mean	683	681	627	642
Corr. to Grad QPA	.182	.316	.366	.303
GRE ANALYTIC:				
Sample Size	186	64	74	55
Mean	583	607	545	537
Corr. to Grad QPA	.110	.076	.228	.362
UNDERGRADUATE QUALITY POINT AVERAGE:				
Sample Size	212	72	79	52
Mean	3.21	3.10	3.07	2.74
Corr. to Grad QPA	.250	.144	.246	.062

A summary of the interplay between independent variables and each of the categories follows.

Relationship of the Independent Variables to On-Campus Degree Students Enrolled in the Department of Electrical and Computer Engineering (Category #1)

Students in the sample share the following (mean) characteristics: Age-25; Degree Age-2; GREV-512; GREQ-683; GREA-583; Undergraduate QPA-3.21; Graduate QPA-3.25.

Stepwise regression resulted in an _r_ square of 16.1% at the .01 level of significance (15.7% adjusted for degrees of freedom). Key variables identified included degree age, GRE Quantitative test, and undergraduate quality point average (Predicted Graduate QPA = 82 + 3.69 Degree Age + 1.28 GREQ + 0.461 Undergraduate QPA). An insignificant analysis of variance (F=0.09) rejected the hypothesis that statistically important variations existed between the actual and predicted performance for students in this category.

None of the correlations of independent variables to graduate performance offered strong relationships. The strongest are evident among undergraduate performance (correlation of .250, significant (.01) r square of only 6.3%) and degree age (correlation of .226, significant (.05) r square of only 5.1%). Little of significance is observed when either of these two variables are divided into constituent groups. In only one instance, degree age older than five, did a statistically significant relationship exist. Here, the correlation was .397 and the predictive value, 15.8% (13.4% adjusted for degrees of freedom) was significant to the .05 level.

Analysis of variance for degree age and performance was significant (.05) in in finding a main effect to performance. The ANOVA for undergraduate QPA was similarly significant to the .01 level. Follow-up Scheffes indicated significant variation in performance between students at the

0-3.00 and 3.51-4.00 undergraduate levels. However, no significant differences were found between those with undergraduate averages of 3.01-3.50 and 3.51-4.00.

The interactions of the remaining variables to graduate quality point average are of less significance. Correlations between Age, GREV, GREQ, and GREA to performance are only .161, .133, .182, and .110. No significant relationships emerged between any of these variables and performance when they were subdivided into levels.

A table of statistically significant relationships between the independent variables and the sample's graduate performance offers the following:

TABLE #80

SUMMARY OF STATISTICALLY SIGNIFICANT RELATIONSHIPS BETWEEN THE INDEPENDENT VARIABLES AND GRADUATE PERFORMANCE OF ON-CAMPUS DEGREE STUDENTS
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FACTOR	CORRELATION TO PERFORMANCE	r SQUARED	r SQUARED CORREC. FOR DEG OF FREED.	SIGNFCNCE
Age				
All	.161	2.6%	2.1%	.05 Level
Degree Age				
All	.226	5.1%	4.7%	.01 Level
5+	.397	15.8%	13.4%	.05 Level
GREQ				
All	.182	3.3%	2.8%	.01 Level
Ugrad QPA				
All	.250	6.3%	5.0%	.01 Level
3.51/4.00	.232	5.4%	4.1%	.05 Level
Stepwise R				
Degree Age + GREQ + Ugrad QPA	.401	16.1%	15.7%	.01 Level

The data offers the following observations when characterizing on-campus degree students in the Department of Electrical and Computer Engineering.

A significant (.05) main effect is found between age and performance. Significant performance differences exist between students aged 26-30 from those 31 or older. The mean performance of the oldest group is higher than that for younger students. Students aged 20-25 perform at a mean higher level than students from 26-30.

Degree age is a significant but minor predictor of performance. The hypothesis suggesting that variation in degree age does not relate to variation in graduate quality point average is statistically rejected (.05). Trends in mean performance indicate that as student degree age grows older, graduate quality point average improves.

No main effect is found between GRE Verbal and performance. However, data indicate that mean graduate performance improves with higher scores on the GREV.

A statistically significant (.01) main effect is found between performance and the GRE Quantitative test. Post-hoc analysis finds significant differences and rejects the notion that no variation in student performance will result from differences in test scores between individuals in the 601-700 and 701+ groups. Individuals with a mean GREQ score above 700 have a mean graduate performance of 3.39. Students with GREQ scores from 601 to 700 exhibit a mean performance of 3.14.

No main effect is found between graduate performance and the GRE Analytic test.

The undergraduate quality point average is a significant but low-level predictor of graduate performance. Trends indicate that students with higher mean undergraduate QPA's perform at a mean higher graduate level. A statistically significant (.01) main effect is found between undergraduate QPA and graduate performance.

Relationship of the Independent Variables to Off-Campus Degree Students Enrolled in the Department of Electrical and Computer Engineering (Category #2)

Students in the sample share the following (mean) characteristics: Age-31; Degree Age-7; GREV-557; GREQ-681; GREA-607; Undergraduate QPA-3.10; Graduate QPA-3.44.

As such, members of this group were usually older than on-campus students and had higher mean scores on the GRE Verbal and Analytic tests. The difference between the mean scores on the GREQ was only 2 points. Though on-campus students had a mean higher undergraduate quality point average, mean graduate performance levels favored off-campus students.

The GRE Quantitative test offered the strongest correlation to performance (.316). When subjected to regression analysis, the GREQ predicted 10.0% of the activity (8.7% corrected for degrees of freedom) and was significant to the .01 level. No grouping within the GREQ, other than mean scores of 701 or above, offered a significant relationship to performance. In this instance, the GRE score correlated .433 to graduate quality point average and when subjected to regression analysis, predicted 18.7% (16.0 adjusted for degrees of freedom) to the .05 level.

The analysis of variance for GREQ and performance rejected the notion (.05) that differences in performance could not be accounted for through variation in GREQ score. Post-hoc analyses found significant performance differences among students with GREQ scores between 200-600 and above 700. A similar null hypothesis could not be rejected for students with scores ranging from 601-700 and those with scores above 700.

The same was not the case with results from the ANOVA on the GRE Verbal test and performance whose interactivity offered the next highest correlation, .217. Neither the GREV nor its subgroups offered statistically significant predictors when subjected to regression analysis with graduate grades.

The remaining variables each offered very low correlations to performance (Age: .102; Degree Age: .105; GRE Analytic: .076; Undergraduate QPA: .144). Regression analysis resulted in only one instance of variables or their subgroups indicating significant predictive values to graduate performance. The sole significant instance was degree age ranging from 6 to 10 years which offered a high correlation of .507 and was a statistically significant (.05) predictor for nearly 26% of the sample (21.8% when adjusted for degrees of freedom). This statistic is of consequence not only for its high (for this study) correlative values, but also for the support found throughout the research indicating that student performance does not necessarily suffer with increased age.

A table of statistically significant activities follows:

TABLE #81

SUMMARY OF STATISTICALLY SIGNIFICANT RELATIONSHIPS BETWEEN THE INDEPENDENT VARIABLES AND GRADUATE PERFORMANCE OF OFF-CAMPUS VIDEO-BASED DEGREE STUDENTS DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FACTOR	CORRELATION TO PERFORMANCE	r SQUARED	r SQUARED CORREC. FOR DEG OF FREED.	SIGNFCNCE
Degree Age				
6-10	.507	25.7	21.8	.05 Level
GREQ (Same as Stepwise Regression for this category)				
All	.316	10.0%	8.7%	.01 Level
701 +	.433	18.7%	16.0%	.05 Level

The data offers the following observations when characterizing off-campus degree students in the Department of Electrical and Computer Engineering.

> No main effect is found between age and mean performance. Neither age nor its levels offer statistically significant relationships to graduate performance among off-campus ECE students.
>
> Though trends exist indicating a positive relationship between degree age and graduate performance, analysis of variance finds no main effect.
>
> Though trends indicate a positive relationship between GRE Verbal test scores and performance, no statistically significant relationships exist. Analysis of variance finds no main effect between GREV and performance.

The GRE Quantitative test is a statistically significant (.01) but low (10.0%) predictor of graduate quality point average. The hypothesis suggesting that variations in GREQ scores do not relate to changes in performance is statistically rejected (.05). Post-hoc analysis indicate significant differences in performance between the 200-600 and 701+ levels (.05) but not between the 200-600 and 601-700 or 601-700 and 701+ levels. Trends clearly indicate that GREQ scores and graduate performance are positively related.

The GRE Analytic test offers no significant relationship to performance and trends are not evident which indicate stronger mean graduate performance with higher mean GREA scores. Data subjected to analysis of variance accept the hypothesis suggesting that variation in graduate quality point average is not statistically relation to variation in mean GREA score.

A student's undergraduate quality point average has no statistically significant relationship with graduate performance. (Low sample size reduces the reliability of this statement. See Chapter 4 discussion on actual versus predicted graduate performance for students in this category.) Though trends indicate that higher undergraduate average is positively related to mean performance, data subjected to analysis of variance find no main effect between undergraduate and graduate quality point averages.

Analysis of Relationship of Independent Variable to Off-Campus Video-Based Non-degree Graduate Students Enrolled in Courses offered through the Department of Electrical and Computer Engineering

Data available for students in this category is limited to graduate quality point average and chronological age at the point of initial enrollment. Non-degree students generally are the same age as their off-campus degree-seeking colleagues but have a lower mean graduate performance.

Age continues to suggest little relevance to graduate quality point average. Its overall correlation to performance is .054 and it provides no significant predictive capability. The only significant relationship existing within the variable is the range of age from 20 to 25, the youngest group. This level offered a correlation of .185 and was able to significantly (.05) predict only 3.4% of the activity (2.7% corrected for degrees of freedom).

The paucity of available data allows only for the following.

TABLE #82

SUMMARY OF STATISTICALLY SIGNIFICANT RELATIONSHIPS BETWEEN THE INDEPENDENT VARIABLES AND GRADUATE PERFORMANCE OF OFF-CAMPUS VIDEO-BASED NON-DEGREE STUDENTS DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FACTOR	CORRELATION TO PERFORMANCE	r SQUARED	r SQUARED CORREC. FOR DEG OF FREED.	SIGNFCNCE
Age 20-25	.184	3.4	2.7	.05 Level

The data is summarized as follows.

No main effect is found between age and performance. No trends exist suggesting that mean performance relates positively or negatively to student age. Age does not predict performance with statistical certainty.

Relationship of the Independent Variables to On-Campus Degree Students Enrolled in the Department of Industrial Engineering/Operations Research
Category #4

Students in the sample share the following (mean) characteristics: Age-26; Degree Age-3; GREV-468; GREQ-627; GREA-545; Undergraduate QPA-3.06; Graduate QPA-3.35.

The sample's stepwise regression analysis identified student age and GRE Quantitative scores as the combination of variables offering the best predictive value. The operant formula, Predicted Graduate Performance = 268 - 3.29 Age + 0.245 GREQ, was significant (.01) in predicting 22.5% of the behavior (21.5% when adjusted for degrees of freedom). Predicted performance correlated to actual at the .474 level and analysis found no main effect between the two.

The set of independent variables were most strongly related to performance in this category than in any other. Statistically significant relationships were apparent in four out of six instances (Age, Degree Age, GREQ, and Undergraduate QPA. In the remaining two, the correlation to performance for the GREA measured .228 but with insignificant predictive capability. The GREV offered the lowest correlation, .057.

In this category, age and degree age correlate highly to one another (.909). Their similar impact upon graduate performance is thus not surprising. What is notable is that this is the first occurrence of age and degree age becoming important factors. In both instances, the variables correlate negatively to performance (Age: -.338; Degree Age: -.307). When subjected to regression analysis, age will predict 11.4% (10.3% adjusted for degrees of freedom) of the sample's behavior and was significant to the .01 level. Degree age was statistically significant to the .01 level and predicted 9.4% (8.3 adjusted for degrees of freedom) of the activity.

Main effects are found to the .01 level for age and performance. Scheffe tests further indicate that significant differences existed between students ranging from 26-30 versus those who were older.

No main effect was found between degree age and performance.

When both age and degree age are subdivided into constituent groups, negative correlations to performance are noted at the upper and lower levels. Only in the mid-range are correlations positive.

Note the following:

TABLE #83

RELATIONSHIPS OF AGE GROUPS TO PERFORMANCE

	GRAD QUALITY POINT AVE FOR			
FACTOR	ALL	AGE 20-25	AGE 26-30	AGE 31+
Sample Size	83	50	23	9
Mean QPA	3.347	3.453	3.381	2.730
StDev	.603	.439	.511	.114
Corr. to Grad QPA	-.338	-.165	.313	-.196
r squared	11.4	2.7	9.8	2.8
r squared Adj DF	10.3	0.7	5.5	0
Level of Sign	.99	No	No	No

TABLE #84

RELATIONSHIP OF DEGREE AGE GROUPS TO PERFORMANCE

	GRAD QUALITY POINT AVE FOR			
FACTOR	ALL	DEGREE AGE 0-1	DEGREE AGE 2-3	DEGREE AGE 4+
Sample Size	83	40	21	22
Mean QPA	3.347	3.365	3.512	3.156
StDev	.603	.502	.389	.862
Corr. to Grad				

QPA	-.307	-.301	.120	-.361
r squared	9.4	9.0	1.4	13.8
r squared Adj DF	8.3	6.6	0	8.7
Level of Sign	.99	No	No	No

Though data is not statistically significant, the trends illustrate a negative performance between age and degree age to performance in all but the subgroups of individuals who combine practical experience with quantitative skills. This combination of factors, required for success in the IEOR curriculum, is most evident among those who have been out of school long enough to gain real-world experience but not so long as to have lost their quantitative skills.

The import of quantitative skills are reflected in the correlation of the GREQ to graduate performance (.366). This factor predicted 13.4% (12.3% corrected for degrees of freedom) to the .01 level. The following indicate the positive relationships between the GREQ and performance.

TABLE #85

RELATIONSHIP OF GRE QUANTITATIVE
TEST SCORES TO GRADUATE PERFORMANCE
ON-CAMPUS IEOR STUDENTS

GRE QUANT SCORE	MEAN GRAD QPA

200-500	2.57
501-600	3.29
601-700	3.40
701+	3.62

Analysis of variance noted a main effect between GREQ and performance to the .01 level. Though post-hoc analyses do not indicate statistically significant differences among students scoring 200-500 and 501-600, 501-600 and 601-700, and 701 and above, differences were found between those scoring from 200-500 and those with scores above 700.

Positive trends are also found between performance and the undergraduate quality point average. Although significant to the .05 level, the predictive capability is only 6.1% (4.8% adjusted for degrees of freedom). No main effects are found through analyses of variance.

A subgroup within the GRE Verbal variable offers startling relationship to graduate performance. GREV scores above 600 offered a -.816 correlation to performance with a predictive value of 66.5% (61.8% adjusted for degrees of freedom), and was significant to the .01 level. While sample size consisted of only nine students, and no main effect was found through analysis of variance, the high values recorded obviously indicate that this factor should be subjected to future research activities.

A table of statistically significant activities follows:

TABLE #86

SUMMARY OF STATISTICALLY SIGNIFICANT RELATIONSHIPS BETWEEN THE INDEPENDENT VARIABLES AND GRADUATE PERFORMANCE OF ON-CAMPUS DEGREE STUDENTS
DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

FACTOR	CORRELATION TO PERFORMANCE	r SQUARED	r SQUARED CORREC. FOR DEG OF FREED.	SIGNFCNCE
Age All	-.338	11.4%	10.3%	.01 Level
Degree Age All	-.307	9.4%	8.3%	.01 Level
GREV 601+	-.816	66.5%	61.8%	.01 Level
GREQ All	.366	13.4%	12.3%	.01 Level
Ugrad QPA All	.246	6.1%	4.8%	.05 Level
Stepwise R Age+GREQ	.474	22.5%	21.5%	.01 Level

The data allow the following observations when characterizing on-campus degree students in the Department of Industrial Engineering/Operations Research.

Age is a statistically significant predictor for graduate performance with correlations indicating that performance diminishes with age. A significant (.01) main effect is found between age and performance. Post-hoc analysis indicates significant (.05) variations in performance between students aged 26-30 from those who are older.

Degree age is a statistically significant (.01) but low level predictor of graduate performance. Although trends indicate that students with degree ages between two and three outperform students in all other groups, no main effects were found between degree age and performance.

Trends indicate that, with the exception of those scoring above 601 on the GRE Verbal, graduate performance will increase with higher GREV scores. Main effects are not found between performance and the GREV.

Performance on the GRE Quantitative test is a statistically significant (.01) predictor of graduate quality point average. Trends indicating higher graduate performance with higher GREQ scores are reinforced by the analysis of variance which offer a main effect between the test and performance. Post-hoc analyses indicate that significant differences in performance are found between students with scores between 200-500 from those with GREQ scores above 700.

Trends indicate higher graduate performance with higher scores on the GRE Analytic test, but the GREA does not offer significant statistical relationship to the graduate quality point average. Analysis of variance finds no main effect between performance and GREA scores.

Although trends indicate that higher undergraduate performance relates positively to graduate performance, and that the undergraduate record is a statistically significant (.05) predictor of graduate grades, analyses of variance do not reject the contention that differences at the undergraduate level do not account for differences in the graduate program.

Relationship of the Independent Variables to Off-Campus Video-Based Degree Students in the Engineering Management Concentration (Department of Industrial Engineering/ Operations Research (Category #5)

Students in the sample share the following (mean) characteristics: Age-31; Degree Age-5; GREV-505; GREQ-642; GREA-537; Undergraduate QPA-2.74; Graduate QPA-3.41. As such, Engineering Management students were generally five years older than on-campus students and had higher mean Verbal and Quantitative GRE test scores. Resident graduate students had higher mean performances on the GRE Analytic test and undergraduate grade point average. Off-campus students exhibited a higher mean graduate grade point average.

The stepwise regression for this sample indicated only the GRE Analytic test score as providing the best fit for all combinations of independent variables. The predicted graduate average resulting from the formula, Predicted Graduate QPA = 270 + 0.132 GREA correlated .297 to actual performance and predicted 8.8% of the relationship (7.1% adjusted for degrees of freedom). It was significant to the .05 level.

Age, degree age, and undergraduate quality point average are statistically insignificant in their relationships to graduate performance. The trend seen first among on-campus students wherein only the mid-range of degree age levels offered positive correlation to performance continues among Engineering Management students. Negative correlations are observed when the degree age ranges are 0-1 (-.047) and above six (-.054). When the range is between 2 and 5 years, the correlation to performance is .355, all being insignificant. Though the analysis of variance for degree age and performance finds no main effect, trends do indicate a positive relationship between mean performance and degree age.

Off-campus students differ from their on-campus colleagues in that there are positive (but insignificant) correlations to performance within all of the age groups, with an especially positive correlation (.411) among those in the 31-35 age range. Note that in Category #4, the correlation between age and degree age was very high. In Category #5, it drops to .441. Trends indicate no clear relationship between age and performance and the variable's analysis of variance offers no main effect.

The same can be said for the relationship of undergraduate quality point average to graduate performance. No trend or statistically significant relationship are observed either within or between the groups.

Significant relationships were found in the GRE Verbal, Quantitative, and Analytic tests, but not within the constituent groups. The Verbal test (correlation of .297) significantly (.05) predicted performance for only 8.8% of the sample (7.1% when corrected for degrees of freedom). However trends, unsupported by analyses of variance offering no main effect, indicated that mean performance might be expected to increase with higher GREV scores.

The relationship of the GRE Quantitative test to performance offered similar results. The GREQ offered significant (.05) but low level predictive capability (9.2%; 7.4% adjusted for degrees of freedom) and no main effect was found from analysis of variance.

Greater significance was found with the relationship of the GRE Analytic test to graduate performance (correlation of .362). Predictive capability rose to 13.1% (11.9% adjusted for degrees of freedom) and was significant to the .01 level.

The table indicating statistically significant relationships follows.

TABLE #87

SUMMARY OF STATISTICALLY SIGNIFICANT RELATIONSHIPS BETWEEN THE INDEPENDENT VARIABLES AND GRADUATE PERFORMANCE OF OFF-CAMPUS DEGREE STUDENTS-ENGINEERING MANAGEMENT PROGRAM DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH CATEGORY #5

FACTOR	CORRELATION TO PERFORMANCE	r SQUARED	r SQUARED CORREC. FOR DEG OF FREED.	SIGNFCNCE
GREV				
All	.297	8.8%	7.1%	.05 Level
GREQ				
All	.303	9.2%	7.4%	.05 Level
GREA (Same as Stepwise Regression)				
All	.362	13.1%	11.5%	.01 Level

Analysis of the data support the following conclusions.

Age is not a statistically significant predictor of performance and its analysis of variance offers no main effect.

Although trends illustrate stronger performance with increased in degree age, the variable offers no statistically significant relationship to performance and its analysis of variance offers no main effect.

The GRE Verbal test offers a statistically significant (.05) but weak relationship to graduate performance. Trends indicate that increased performance on the GREV will result in increased graduate quality point average however, the analysis of variance offers no main effect and its null-hypothesis is accepted.

The GRE Quantitative test is a statistically significant (.05) but weak predictor of graduate performance. The analysis of variance offered no mean effect and accepted the null-hypothesis suggesting that variation in graduate performance is not related to variation in GREQ score.

The GRE Analytic test is a statistically significant (.01) predictor of graduate performance. Analysis of variance indicates the existence of a main effect (.01) and hence rejects the hypothesis suggesting that variation in performance is not statistically related to variation on GREA test score.

The undergraduate quality point average is not a statistically significant predictor of graduate performance. No trends are indicated and the analysis of variance accepts the null-hypothesis.

Relationship of the Independent Variables to Off-Campus Video-Based Non-Degree Students Enrolled in Courses offered by the Department of Industrial Engineering/Operations Research
Category #6

Available data for students in this category is limited to chronological age at the point of initial enrollment and graduate quality point average. Non-degree students are generally the same age as their on-campus degree-seeking counterparts but perform at a mean lower level.

For off-campus non-degree IEOR students, age is not a statistically significant variable when measured against graduate performance.

Data support the following conclusion.

Age is not a statistically significant predictor of graduate performance. No trends indicate increased or diminished performance with increased age. The analysis of variance finds no main effect and accepts the null-hypothesis.

The following is a compilation of all statistically significant correlations at work within individual student categories.

TABLE #88

SUMMARY OF STATISTICALLY SIGNIFICANT RELATIONSHIPS
CATEGORIES #1-#6

FACTOR	CORRELATION TO PERFORMANCE	r SQUARED	r SQUARED CORREC. FOR DEG OF FREED.	SIGNFCNCE
CATEGORY #1: ON-CAMPUS ECE DEGREE STUDENTS				
Age				
All	.161	2.6%	2.1%	.05 Level
Degree Age				
All	.226	5.1%	4.7%	.01 Level
5+	.397	15.8%	13.4%	.05 Level
GREQ				
All	.182	3.3%	2.8%	.01 Level
Ugrad QPA				
All	.250	6.3%	5.0%	.01 Level
3.51/4.00	.232	5.4%	4.1%	.05 Level
Stepwise R Degree Age + GREQ + Ugrad QPA	.401	16.1%	15.7%	.01 Level
CATEGORY #2: OFF-CAMPUS VIDEO-BASED ECE DEGREE STUDENTS				
Degree Age				
6-10	.507	25.7	21.8	.05 Level
GREQ (Same as Stepwise Regression for this Category)				
All	.316	10.0%	8.7%	.01 Level
701 +	.433	18.7%	16.0%	.05 Level

CATEGORY #3: OFF-CAMPUS NON-DEGREE STUDENTS, ELECTRICAL AND COMPUTER ENGINEERING

Age 20-25	.184	3.4%	2.7%	.05 Level

CATEGORY #4: ON CAMPUS DEGREE STUDENTS, INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

Age All	-.338	11.4%	10.3%	.01 Level
Degree Age All	-.307	9.4%	8.3%	.01 Level
GREV 601+	-.816	66.5%	61.8%	.01 Level
GREQ All	.366	13.4%	12.3%	.01 Level
Ugrad QPA All	.246	6.1%	4.8%	.05 Level
Stepwise R Age+GREQ	.474	22.5%	21.5%	.01 Level

CATEGORY #5 OFF-CAMPUS DEGREE STUDENTS: ENGINEERING MANAGEMENT PROGRAM, DEPARTMENT OF INDUSTRIAL ENGINEERING/ OPERATIONS RESEARCH

GREV All	.297	8.8%	7.1%	.05 Level
GREQ All	.303	9.2%	7.4%	.05 Level
GREA (Same as Stepwise Regression) All	.362	13.1%	11.5%	.01 Level

CATEGORY #6: OFF-CAMPUS NON-DEGREE STUDENTS: DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

No significant relationships recorded

RELATIONSHIP OF ACTUAL TO PREDICTED GRADUATE PERFORMANCE

The reported research included analyses of variance combined with post-hoc analyses seeking main effects between a set of independent variables and graduate performance between on and off-campus degree students. Data indicated no significant variation in graduate performance between on and off-campus degree students in either the Department of Electrical and Computer Engineering or Industrial Engineering/Operations Research. As such, the research validates non-tutored videotape instruction as an effective delivery system. It argues against those who contend that only with tutor-supported-ITV can effective instruction be transmitted.

To further validate this instructional modality, actual graduate performance of off-campus degree students was compared to predicted performance levels established for on-campus students. This argument assumes that predicted on-campus performance is nominally acknowledged as constituting the accepted norm. If off-campus students met levels established by their on-campus peers and if the primary difference between the two samples consisted of live versus videotaped instruction then one could argue that no diminishment of learning can be attributed to delivery systems.

This argument requires the assumption that performance is strongly-related to the variables established in this study as well as that which presumes the samples to be similar in all ways but instructional delivery systems. Neither is the case. The existence of variables beyond those measured are clearly indicated by low levels of correlation and predictiveness. However, given that quantifiable factors noted in this study are widely accepted, results achieved from the analyses are acceptable for the purposes noted.

The on-campus predictor for ECE degree students was established from the stepwise regression of all variables against graduate performance. The resulting formula was Predicted Performance = 82 + 3.69 Degree Age + 1.28 GRE Quantitative + 0.461 Undergraduate QPA. On-campus predictors (mean graduate quality point average of 3.36) correlated .354 with actual off-campus grades (mean graduate performance of 3.44). The model significantly (.01) fit 12.6% (11.1% when adjusted for degrees of freedom) of the sample.

The analysis of variance found no main effect between the actual and predicted performances. It is then asserted that no statistically significant differences were present between the actual graduate performance of off-campus video-based ECE students and the standard set for them by on-campus student performance predictors. Stated another way, off-campus ECE student performance was not diminished through the utilization of the technology.

The actual performance of off-campus degree students in the Engineering Management concentration were compared to levels of predicted performance established through regression analysis of actual on-campus IEOR graduate student grades. The regression model resulted in the formula Predicted Graduate QPA = 268 -3.29 Age + 0.245 GRE Quantitative. Actual off-campus students performance (mean QPA of 3.41) exhibited a .365 correlation to on-campus predicted values (mean predicted QPA of 3.23). When subjected to regression analysis, the predicted quality point average yielded an $\underline{r}$ square of 13.3% (11.7% when corrected for degrees of freedom) which was significant to the .01 level.

When off-campus actual grades were subjected to analysis of variance with on-campus predicted performance, the null-hypothesis claiming no significant differences was statistically (.05) rejected. This would indicate that there was a significant difference between the actual grades received compared to what would have been expected for the off-campus students. Indeed, the mean actual quality point average was more than 0.17 higher than that anticipated for them.

Though this data is accurate as far as it goes, a caveat is required. Courses offered off-campus by videotape through the Department of Industrial Engineering/Operations Research include a narrower band of total semester offerings then is normally available through Electrical and Computer Engineering. In effect, the IEOR Department offered a lower percentage of its normal courses on tape than did the ECE department. As a result, Engineering Management students were "batched" into a narrower range of courses than were available to and selected by on-campus IEOR graduate students. The predictive formula did not take this into account and casts doubt on the inferences derived from the ANOVA.

Results fall further into question when the Engineering Management courses are evaluated qualitatively. While they were taped versions of the courses offered to on-campus students, and as such no different, their subject-matter was less quantitatively oriented then was the larger sample of on-campus courses. In many instances, courses available to off-campus students used project or case study approaches which were common to the experience of the working engineering manager. While this is not to intimate that the curriculum was less rigorous, both the narrower band of available courses and their different orientation diminish the utility of the on-campus predictor for purposes of this analysis.

The validity of the ANOVA for ECE off-campus students is not similarly tainted as a much broader selection of coursewear was offered off-campus and there was less variation in their quantitative nature. As such, the assertion claiming no statistical difference between off-campus actual and on-campus predicted performance holds.

COMPARISON OF COURSE GRADES BETWEEN ON AND OFF-CAMPUS STUDENTS ENROLLED IN THE SAME COURSE

To this point, research activities have focused on determining differences and relationships among and between variables interacting with mean graduate performance. To complete the analysis, individual course sections were reviewed to determine whether significant performance differences existed between on and off-campus video-based degree students.

To affect this process, each individual course taken by the students in the sample was reviewed. A course section was included for analysis if its enrollment reflected course registrations by at least two on and two off-campus degree students (regardless of the number of off-campus non-degree students registered for the course). If a course section met these criteria, off-campus non-degree students were included in the analysis of variance.

This selection process yielded 53 course sections for study. Thirty-seven were offered to on and off-campus Electrical and Computer Engineering students (one of which was offered by the Department of Computer and Information Sciences). The remaining 16 were offered through the Department of Industrial Engineering/Operations Research to resident on-campus students and participants in the Engineering Management program.

Each course section was subjected to analysis of variance to determine whether significant differences existed between on and off-campus student performance. In those instances where significant variation was observed, post-hoc analyses were exercised to remove the non-degree students from the analysis. The Scheffe would then indicate only whether the significant differences existed between the degree student samples.

In twenty-eight of the Electrical and Computer Engineering (and Computer and Information Sciences) courses test, analyses of variance found no statistically significant differences between on and off-campus degree students. In five of the remaining courses, the main effect was evident at the .01 level. In the remaining three, the null-hypothesis was rejected to the .05 degree of probability.

In the eight courses which indicated significant "F's", post-hoc analyses (Scheffe) were conducted to remove the effect of the non-degree students. In seven of eight instances, removing the effects of the non-degree students also removed the statistically significant performance differences.

In the remaining course, there were two off-campus enrollees, both of whom received a grade of "AB". The mean performance for the on-campus students was 2.93. The rejection of the null-hypothesis was significant to the .05 level of certainty.

When the ECE courses are taken as a whole, 35 out of 36 indicate the existence of no significant variation in performance between groups within the same course. This amounts to a factor of better than 97%.

Performance patterns were much the same in selected course sections in IEOR. In nine of the sixteen course sections, student category was found not to be a significant factor. In the remaining seven courses, post-hoc analyses removing the effect of the non-degree students also removed the significant variation caused by category.

Therefore, in only one of fifty-one course sections was statistically significant evidence found to indicate that variation in performance could be attributed to student category. In 98% of the cases, it was not the case. This provides further support for the contention that off-campus degree student performance is not significantly at variance with the performance of on-campus students learning in the traditional way.

RESTATEMENT OF CONCLUSIONS

1. Off-campus video-based degree-program graduate students in the Department of Electrical and Computer Engineering are usually older and have older degree ages then their on-campus counterparts. They exhibit higher mean scores on the GRE Verbal and Analytic tests and a lower mean score on the GRE Quantitative then do resident ECE graduate students. On-campus students have a higher mean undergraduate quality point average. Off-campus degree students have a higher mean graduate average.

Off-campus non-degree ECE students are approximately the same age as off-campus degree students but show lower graduate performance then either on or off-campus degree students.

TABLE #89

MEAN CHARACTERISTICS
ELECTRICAL AND COMPUTER ENGINEERING STUDENTS

	On-Campus Degree Students	Off-Campus Degree Students	Off-Campus Non-Degree Students
Age	25	31	30
Degree Age	2	7	
GREV	512	557	
GREQ	683	681	
GREA	583	607	
UGrad QPA	3.21	3.10	
Grad QPA	3.25	3.44	3.21

2. Off-campus video-based degree-program graduate students in the Department of Industrial Engineering/ Operations Research are usually older and have older degree ages then their on-campus counterparts. They exhibit higher mean scores on the GRE Verbal and Quantitative tests and a lower mean score on the GRE Analytic then do resident ECE graduate students. On-campus students have a higher mean undergraduate quality point average. Off-campus degree students have a higher mean graduate average.

Off-campus non-degree IEOR students are approximately the same age as off-campus degree students but show lower graduate performance then either on or off-campus degree students.

TABLE #90

MEAN CHARACTERISTICS
INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

	On-Campus Degree Students	Off-Campus Degree Students	Off-Campus Non-Degree Students
Age	26	31	31
Degree Age	3	5	
GREV	468	505	
GREQ	627	642	
GREA	545	637	
UGrad QPA	3.06	2.75	
Grad QPA	3.35	3.41	3.06

3. The following is useful for purposes of student counseling for those considering study in electrical and computer engineering graduate programs, on or off-campus (in a videotaped delivery system). The table offers mean variable values for the highest and lowest performers.

TABLE #91

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ON-CAMPUS DEGREE STUDENTS			OFF-CAMPUS DEGREE STUDENTS	
Best	Worst	VARIABLE	Best	Worst
31+	26-30	Age	20-25	31+
5+	0-1	Degree Age	2-3	4+
701+	200-400	GREV	501-601	200-400
701+	601-700	GREQ	701+	200-500
701+	501-601	GREA	601+	200-500

3.51-4.00	0-3.00	Ugrad QPA	3.51-4.00	0-3.00

4. The following is useful for purposes of student counseling for those considering study in industrial engineering/operations research or its subfield of engineering management, on or off-campus (in a videotaped delivery system). The table offers mean variable values for the highest and lowest performers.

TABLE #92

DEPARTMENT OF INDUSTRIAL ENGINEERING/OPERATIONS RESEARCH

ON-CAMPUS DEGREE STUDENTS			OFF-CAMPUS DEGREE STUDENTS	
Best	Worst	VARIABLE	Best	Worst
31-35	20-25	Age	20-25,31-35	36+
11+	0-3	Degree Age	6+	0-1
601+	200-500	GREV	601+	200-400
701+	200-600	GREQ	701+	601-700
601-700	501-600	GREA	601-600	200-500
3.51-4.00	0-3.00	Ugrad QPA	3.01-4.00	2.51-3.00

5. There are no significant differences in graduate performance between on and off-campus video-based degree students in the Department of Electrical and Computer Engineering. This holds for mean graduate performance between student categories, for mean graduate performance of

off-campus degree students when compared to on-campus predicted levels of performance, and on a course-by-course basis.

6. There are no significant differences in graduate performance between on campus graduate students in the Department of Industrial Engineering/Operations Research and off-campus degree students in the IEOR Engineering Management Master's program. This holds for mean graduate performance between categories of degree students and on a course-by-course basis. Though statistically significant variation was observed between the actual graduate performance of off-campus Engineering Management students when compared to on-campus performance predictors, this is questioned due to variation in the breadth and type of available off-campus video courses.

7. Off-campus non-degree students enrolled in graduate courses offered by both academic departments perform of significantly lower levels than do either of the two degree student categories. Student age is not a significant factor in accounting for this variation in performance. Additional research is required to determine those factors contributing to these performance differences.

8. The attrition rate among off-campus Electrical and Computer Engineering non-degree students exceeds 50%. More than 30% of off-campus non-degree IEOR students withdraw from courses without achieving a passing or failing grade. Additional research is required to determine those factors contributing to this phenomenon.

9. The research identified numerous statistically significant but low correlations between the independent variables, acting singularly and in concert, and graduate performance. While a degree of this may result from grade compression, other factors are clearly impacting upon graduate quality point averages. Further research, aimed at identifying these variables, is required.

CONCLUSION

America's dramatic need for new and revitalized engineering talent, higher education's limited resources, and recent developments in technology have combined to foster the expansion of instructional television as a delivery system for off-campus graduate engineering education. Never advertised as a panacea to resolve the panoply of industry's training concerns, ITV is increasingly viewed as a solution to the problem of industrial access of higher education's faculty and instructional resources.

Experience and literature, while promoting the efficacy of mediated education, have long argued in favor of the human factor, e.g. tutorially-supported videotaped education. Tutors, and group size sufficient to promote local off-campus discussion have been promoted. However, developments in telecommunications technologies, expanded course offerings, and specialized training needs among small and widely dispersed pockets of engineers auger an increase in instances of one or two individuals enrolled in courses at particular locations. No corporation, large or small, can easily afford or administer tutorial programs for large numbers of very small classes. The research offered throughout this effort indicate that tutors, though desirable, are not necessary for effective learning (as measured by graduate quality point average). As such, the non-tutored version of videotaped or satellite-delivered instruction can be accepted as a proven modality for effectively delivering graduate engineering instruction. It then joins the arsenal of systems allowing higher education and corporate engineering to work further to resolve the engineering manpower crisis without additional strain on faculty in America's system of engineering higher education.

NOTES

CHAPTER 1

(1)
Botkin, J., Dimancescu, D., and Stata, R. Global Stakes: The Future of High Technology in America. Cambridge, MA: Ballinger Publishing Co., 1982, p. 4.

(2)
See Rudolf, Frederick. The American College and University: A History. New York: Random House, 1962.

(3)
Rudolf, 1962, p. 5.

(4)
Rudolf, 1962, p. 248.

(5)
Botkin, 1982, p. 29.

(6)
Aerospace Industries Association of America. Meeting Technology and Manpower Needs through the University/Industry Interface: An Aerospace Industry Perspective. Washington, D. C.: The Aerospace Research Center, 1983, p. 9.

(7)
Id., p. 10.

(8)
See John, James, E. A. Quality of Engineering Education II. Washington, D. C.: National Association of State Universities and Land-Grant Colleges, January, 1985, pp. 10-11.

(9)
Foley, Howard. Engineering Manpower Shortage--Myth or Reality. Paper delivered at the Dean's Seminar, School of Engineering, University of Massachusetts, Amherst, MA, October 11, 1984.

(10)

Fano, R. M., Bruce, J. D., Siebert, W. M., Smullin, L. D. Lifelong Cooperative Education: Report of the Centennial Study Committee. Cambridge, MA: Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, October, 1982, p. 6.

(11)

Baldwin, L. V. Testimony before House Committee on Science and Technology, Washington, D. C., March 3, 1981.

(12)

Hubbard, Pat H. Plan for Action to Reduce Engineering Shortage...With Supporting Data, Palo Alto, CA: American Electronics Association, October, 1981, p.4.

(13)

Braddock, D. The Job Market for Engineers: Recent Conditions and Future Prospects. Occupational Outlook Quarterly. Washington, D. C.: Bureau of Labor Statistics, Summer 1983, p. 6.

This report probably overstated future requirements because of biases inherent in its methodology. Projections based on company plans are generally upwardly biased because companies plan for and expect growth, but many companies plan to increase their market share, even though one company can only increase its share at another's expense. Such overly optimistic estimates are particularly strident in defense-related fields because while only one firm can be awarded each major defense contract, each firm is likely to assume that it will get the contract when responding to a survey. Another drawback of this survey is that most business firms tend to see the future as very much like the present. These projections of rapid growth may, therefore, be extrapolations of the rapid growth of the past few years rather than a realistic assessment of long-term trends.

(14)

Lee, Neville. The Demand for Engineers in Massachusetts. Prepared by the Bank of Boston for the Board of Regents of Higher Education, Commonwealth of Massachusetts, February 15, 1984. Note, however, that this report did suggest the shortage of computer specialists (including computer systems analysts and programmers) and a potential shortage of electrical and electronic engineers in its projections through 1987 (p7).

(15)

Vetters, Betty M. Opportunities in Science and Engineering. Washington, D. C.: Scientific Manpower Commission, November, 1984, p. 90. The author offers the following data compiled by the National Science Foundation:

Supply/Demand Balance of Scientists and Engineers
Based on a Net-Mobility Supply Model
1983 and 1987

OCCUPATION	1983 TOTAL SUPPLY	1983 DEMAND	1983 BALANCE AS % OF SUPPLY	1987 TOTAL SUPPLY	1987 DEMAND	1987 BALANCE AS % OF SUPPLY
	(In Thousands)					
Total Engr's	1,217.2	1,207.6	0.8	1,437.3	1,432.1	1.0
Aero/Astro	70.0	72.4	-3.4	104.8	109.2	-4.2
Chemical	58.0	55.4	4.5	64.2	60.9	5.1
Civil	171.6	171.5	0.1	190.1	188.9	0.6
Elec/Electrn	347.9	348.9	-0.3	421.3	420.6	0.2
Industrial	114.2	114.9	-0.6	129.8	130.8	-0.8
Mechanical	217.9	214.3	1.7	253.4	248.2	2.1
Mettalgcl	16.3	15.8	3.1	19.2	18.5	3.6
Mining/Petro	28.5	27.6	3.2	32.5	31.6	2.8
Engineers	192.8	186.8	3.1	222.0	214.4	3.4
Cmptr Speclsts	477.7	486.9	-1.9	592.8	603.8	-1.9

(16)

The need for "high tech" talent may even be more intense. This results from the fact that "in most fields of electronics and computers, the master's degree has become, for the most part, the standard level of academic preparation for those engaged in design." Engineering Graduate Education and Research. Washington, D. C.: National Academy Press, 1985, p. 76.

(17)

National Academy of Engineering: Education for the Manufacturing World of the Future. Washington, D. C.: National Academy Press, 1985, p. 24.

(18)

Kahne, Stephen A. A Crisis in Electrical Engineering Manpower. IEEE Spectrum, July, 1981, p. 50.

(19)

National Science Foundation and the U.S. Department of Education. Science and Engineering Education for the 1980's and Beyond. Washington, D. C.: U S. Government Printing Office, 1980, pp. 24-34.

(20)

"Business Week", December 14, 1981, p. 120. Noted in Botkin, 1982, p. 35.

(21)

Statement by Dr. Erich Bloch, Head of the National Science Foundation. Noted in Botkin, 1982, p. 79.

(22)

Botkin, 1982, p. 78.

(23)

"Fortune Magazine", November 2, 1981, p. 112. Noted in Botkin, 1982, p. 82.

(24)

Vision of MITI Policies in the 1980's. Tokyo, Japan: MITI. Noted in Botkin, 1982, p. 33.

(25)

Botkin, 1982, p. 7.

(26)

Botkin, 1982, p. 131.

(27)

Schmaling, George P. Status of Video Based Graduate Engineering Education in the United States. Workshop on Continuing Education for Engineers at Midcareer. Dallas, TX: National Science Foundation Contract No. GY-11304, August, 1974, p. 2.

(28)

Levy, Girard and Newman, Sandy C. A Survey of Continuing Education for Non-Academic Scientists and Engineers. Washington, D.C.: American Society for Engineering Education, National Science Foundation Grant No. SED 7718565, 1979.

(29)

Jones, Russel C., et al., "Enhancing Utilization of Engineers through Continuing Professional Development. Grayson and Biedenbach (Eds.). Proceedings of the 1986 College Industry Education Conference. Washington, D. C., American Society for Engineering Education, 1986, pp. 144-163.

(30)

Fano, 1982, p. 9

(31)

Botkin, 1982, p. 29.

(32)

See Engineering Education Problems: A Guide to Action for NSPE State Societies Washington, D. C.: National Society of Professional Engineers, September, 1982. The following summary is found on page 6 of this report.

Engineering Education Problems
Survey Report Highlights

As of the Fall 1981, there were an estimated 18,000 full-time engineering faculty positions authorized; 13,000 in public school, 5,000 in private schools.

Nine percent, approximately 1,600, of the authorized positions in the nation's engineering schools were unfilled as of Fall 1981; 56% of these unfilled in Fall 1980.

Twenty-four percent of the authorized faculty positions at the Assistant Professor rank were unfilled in Fall 1981; 56% of these unfilled in Fall 1980.

Seventy-one percent of the engineering school reported a decrease in their ability to recruit and retain faculty.

Greater than 70% of the engineering schools reported an increased teaching load and a greater reliance on Teaching Assistants and part-time faculty.

More than 47% of the engineering schools reported that some courses were not being offered.

Over 32% of the schools reported a reduction in research being conducted.

Sixty-six percent of full-time engineering faculty hold tenured positions.

Almost 81% of the full-time engineering faculty hold doctorates.

Over 17% of full-time engineering faculty received their baccalaureate degree from a non-U.S. university.

Less than 3% of the engineering faculty are age 66 or older.

Twenty-two percent of the engineering faculty are age 56 or older.

Nineteen percent of the engineering faculty are age 35 or younger.

Public engineering schools lost almost 24% more faculty members who voluntarily accepted positions in industry than the number gained from coming from industry.

Private engineering schools gained almost 64% more faculty members from industry than the number that voluntarily left for industry.

Fifteen percent of all engineering graduate students are attending schools from which they received their baccalaureate degrees.

Almost 41% of all teaching assistants in engineering graduate schools are foreign students.

(33)

Hubbard, 1981, p. i.

(34)

See College Placement Council, Salary Survey, Formal Report #3, July, 1984. In Vetters, Elizabeth M., 1984, p. 83.

AVERAGE ANNUAL SALARY OFFERS TO BACHELOR'S DEGREE CANDIDATES, 1984

Engineering	$26,276
Aeronautical	$25,836
Chemical	$27,420
Civil/Construction/Sanitary/Transprtn	$22,764
Electrical/Computer	$26,556
Geological	$24,492
Industrial	$25,224
Mechanical	$26,280
Metallurgical/Ceramic/Metallurgy	$26,556
Mining	$24,876
Nuclear/Engineering Physics	$26,388
Petroleum	$29,568
Engineering Technology	$24,936
Computer Sciences	$24,552

(35)

Engineering Education Problems, 1982, p. 3.

(36)

Baldwin, Lionel V., New Modes for Advanced Engineering Education, 1983, p.384.

(37)

John, 1985, p.5

(38)

Engineering Graduate Education and Research, 1985, p.27. For further evidence of the manpower problem among engineering faculty, note the following:

ENGINEERING PH.D. POST GRADUATE PLANS
PERCENT VIEWING ACADEMIA AS A CAREER CHOICE

Year	Percent
1960	31.9
1966	26.3
1970	20.2
1972	17.8
1974	14.9
1976	17.6
1978	17.2
1980	19.2
1982	17.0

(39)

1983-1984 ENGINEERING FACULTY SALARY SURVEY
OVERALL NATIONAL STATISTICS

(9 MONTH TERMS)	MINIMUM	MAXIMUM	AVERAGE
Extraordinary Professors	$28,000	$82,250	$50,023
Professors	$20,657	$79,980	$42,125
Associate Professors	$16,600	$57,959	$33,080
Assistant Professors	$16,050	$47,796	$29,191
Instructors	$12,000	$41,050	$20,906

Source: Hemp, G., and Brunson, J. 1983-1984 Engineering Faculty Salary Survey. Washington, D. C.: American Society for Engineering Education, January, 1984, p. 10. (Even assuming that an average full professor could earn a comparable income during the remaining three months of the year, this would bring him to no more than $56,000. This figure would still be considered low in today's electronic marketplace for comparably credentialed and experienced individuals.

(40)

AVERAGE SALARIES AND ENGINEERS BY EMPLOYMENT AREA
AND EXPERIENCE LEVEL

YEARS OF EXPERIENCE	EDUC	ALL MNFCTRNG (MEDIAN)	CNSTRCT	CNSLTNT	TRNPTN
5-9	25,000	30,000	30,000	28,000	30,912
10-14	30,000	35,000	37,142	35,000	31,387
20-24	34,900	40,150	49,550	44,500	40,845

Source: Engineering Education Problems, 1982, p. 3.

(41)

Data presented is supplied by the National Research Council. It is an aggregate of earning power of all Ph. D. engineers over time.

MEDIAN ANNUAL SALARIES OF DOCTORAL ENGINEERS
BY YEARS SINCE PH. D.

Years in Ph. D.	Median Salary
5 or less	$37,600
6-10	$44,200
11-15	$48,600
16-20	$51,500
21-25	$55,100
26-30	$60,100
Over 30	$58,200

Note: Academic salaries were multiplied by 11/9 to adjust for a full-time scale.

Source: Vetters, 1984, p. 84.

(42)

John, 1985, p. 7.

(43)

Engineering Education Problems, 1982, p. 4.

(44)

Engineering Graduate Education and Research, 1985, p. 33.

(45)

John, 1985, p. 7.

(46)

John, 1985, p. 5.

(47)

Engineering Education Problems, 1982, pp. xii-xiii. Note the following:

U.S. ENGINEERING DEGREES (1950-1980)

	BACHELORS DEGREES			MASTERS DEGREES			DOCTORAL DEGREES		
Year Ending	Foreign Nationals	%	Total	Foreign Nationals	%	Total	Foreign Nationals	%	Total
1970	1,565	4	43,167	2,930	2	16,383	741	20	3,640
1975	2,468	6	38,210	3,250	21	15,773	891	28	3,130
1980	4,895	8	58,742	4,512	26	17,243	982	36	2,751

GRADUATE SCHOOL POPULATION CHARACTERISTICS
ALL STUDENTS

	Public Schools	Private Schools	All Schools
U.S. Students	63.4%	66.7%	64.5%
Immigrants	3.0%	3.1%	3.1%
Non-Immigrants	33.6%	30.2%	32.4%
Own Undergraduates	15.6%	14.1%	15.1%

GRADUATE SCHOOL POPULATION CHARACTERISTICS
POST-MS STUDENTS

	Public Schools	Private Schools	All Schools
U.S. Students	52.8%	58.7%	55.2%
Immigrants	4.4%	2.6%	3.7%
Non-Immigrants	42.8%	38.7%	41.1%
Own Undergraduates	11.0%	7.2%	9.5%

GRADUATE STUDENT CHARACTERISTICS
BY ENGINEERING DISCIPLINE

Engineering Discipline	% Non-Immigrant Foreign-Born Graduate Students Total	Post-MS
Chemical Engineering	39.0%	41.5%
Civil Engineering	35.5%	46.0%
Electrical Engineering	33.0%	42.0%
Mechanical Engineering	33.0%	42.0%

(48)

Engineering Education Problems, 1982, p. 5.

> This trend has already resulted in some very serious problems and portends more in the future. First, it means the pool of potential native-born Americans to fill faculty positions is severely limited. In 1980, according to the National Research Council, 46.3 percent of all engineering doctorates went to non-citizens of the United States, two thirds of whom leave the U.S. after receiving their doctorate.
>
> Secondly, the influx of foreign-born faculty has resulted in significant

communications barriers in the classroom, causing teaching quality to suffer.

A study by the Congressional Research Service, "United States Supply and Demand of Scientists and Engineers: Effects on Defense and Research and Technology," describes another dimension of the non-citizen engineering student concern. The report states, "The Department of Defense is greatly concerned about the increase of foreign national graduate students, the NSF notes, because the DoD must hire U.S. citizens. Due to a significant increase in the number of foreign national students in some science and engineering fields, it is believed that in the near future very few U.S. citizens in these fields will be available for hiring. In addition, foreign students pose a technology transfer problem that is particularly troublesome to the military."

(49)

Engineering Education Problems, 1982, p. viii.

UNFILLED POSITIONS AS A PERCENTAGE OF
AUTHORIZED FULL-TIME POSITIONS
FALL 1981

Engineering Field	Public Schools	Private Schools	All Schools
Aero/Astro	5.9%	2.6%	5.1%
Chemical	9.0%	8.2%	8.8%
Civil	8.7%	6.8%	8.2%
Comp. Sci./Engin.	17.0%	16.8%	17.0%
Electrical	8.8%	7.9%	8.5%
Industrial	11.6%	11.8%	11.6%
Mechanical	9.5%	7.2%	8.9%
All Others	9.3%	7.2%	8.8%
All Schools	9.5%	7.9%	9.0%

(50)

Colleges and universities report that salary and financial benefits were cited as motivating factors in 76% of those instances where faculty left higher education for industry.

Source: Engineering Education Problems, 1982, p. 3.

(51)

Here again the problem is two-fold. Inadequate facilities and equipment prevent research faculty from producing the levels of quantity and quality work expected by themselves, their institution, and their professional peers. Further, inadequate laboratory resources also has a negative effect in terms of undergraduate engineering education--further problemmatic in relation to the problems of engineering supply and demand. As reported by the American Society for Engineering Education:

> Laboratory equipment is outdated. A recent study indicates that equipment in most academic engineering labs is about twice as old as in industrial labs. Further, accreditation results show drastic declines in the effectiveness of laboratory portions of engineering curricula as a result of equipment deficiencies. The Accreditation Board for Engineering and Technology (ABET) reports that over one half of the accreditation visits result in something less than full accreditation. Deficiencies in equipment is a significant element in the majority of these cases.

Source: Engineering Education Problems, 1982, p. 3.

(52)

For example, Dr. Joseph Hogan, reviewing the equipment status of the University of Massachusetts' School of Engineering in "Engineering Education in Massachusetts: Current Trends and Future Directions," reported that the funds that would be required in a one-time expenditure to solely bring the School up to where it should be at the current time totalled $4,500,000. This represented $6,000 per undergraduate, $10,000 per Master's level graduate student, and $25,000 for each Doctoral Candidate.

This should be compared to an average state allocation of $60,000 per year for the support of five departments within the School of Engineering from 1980 through 1984.

STATE-SUPPORTED EQUIPMENT BUDGET
UNIVERSITY OF MASSACHUSETTS SCHOOL OF ENGINEERING
1980-1984

Year	Budget
1984	$33,844
1983	$51,025
1982	$67,984
1981	$92,900
1980	$49,582

(Source: Stone, Harvey R. School of Engineering Report: 1983-1984. Unpublished. College of Engineering University of Massachusetts, Amherst, MA: 1985.)

Hogan further argued the accepted notion that $1,500 is required in equipment support for each undergraduate on a continuing annual basis. Master's students would require $2,500 and $5,000 would be required for each Doctoral student per year. Based upon these criteria, the University of Massachusetts' School of Engineering should have an annual/maintaining equipment budget of $1,100,000.

(53)
Engineering Education Problems, 1982, p. v.

CHANGE IN ABILITY TO RECRUIT AND RETAIN FACULTY

Degree of Change	Public Schools	Private Schools	All Schools
Substantial Increase	4.9%	5.9%	5.3%
Slight/Moderate Increase	6.9%	17.6%	11.2%
No Change	5.9%	22.1%	2.4%
Slight/Moderate Decrease	40.2%	32.4%	37.1%
Substantial Decrease	42.2%	22.1%	34.1%

(54)
Recruitment and Retention of Full-Time Engineering Faculty, Fall, 1980: Higher Education Panel Report No. 52. Washington, D.C.: American Council on Education, October, 1981.

(55)
Botkin, 1982, pp. 131-132.

(56)
Engineering Graduate Education and Research, 1985, p. 51.

(57)

Fano, 1982, p. 37.

(58)

Jones, Russel C., et al. Educational Technology for Quality Engineering Education. Pre-publication abstract, 1986

(59)

Dirr, Peter. Television in Higher Education. In Tate, P. J., and Kressel, M. (Eds.). The Expanding Role of Telecommunications in Higher Education, New Directions for Higher Education, No. 44. San Francisco: Jossey-Bass, December, 1983.

Uses of Television by Higher Education Institutions
(1978-1979)
(2993 Colleges)

Only for instructional purposes	10%
To supplement existing courses	36%
To offer courses over television	25%
No use of television	29%
Total Uses	100%

Allocation of Television Effort
(1978-1979)
(N=2,129)

Instructional Uses	
On-campus credit	44%
On-campus non-credit	8%
Off-campus credit	11%
Off-campus non-credit	3%
Total instructional uses	66%
Non-instructional uses	
Counseling	7%
Outreach	6%
Promotion and recruitment	9%
Other	11%
Total non-instructional uses	33%

(60)

AMCEE is a non-profit, tax-exempt consortium of engineering universities, formed in 1976, to increase the national effectiveness of continuing education for engineers, industrial scientists, and technical managers. Its activities include the development and distribution of media-based graduate and continuing education courses and is headquartered in Atlanta.

AMCEE Members

Arizona State	Auburn
Boston University	Colorado State
Georgia Inst. of Technology	GMI Institute
Illinois Institute of Technology	Iowa State
Massachusetts Institute of Technology	Michigan Tech.
North Carolina State	Northeastern
Notre Dame	Oklahoma State
Polytechnic Institute of New York	Purdue
Southern Methodist	Stanford University
Univ. of Alaska	Univ. of Arizona
Univ. of Florida	Univ. of Idaho
Univ. of Illinois/Urbana-Chmpgn	Univ. of Kentucky
Univ. of Maryland	Univ. of Mass.
Univ. of Michigan	Univ. of Minnesota
Univ. of Missouri/Rolla	Univ. of So. Carolina
Univ. of Southern California	Univ. of Washington

Univ. of Wisconsin/Madison

(61)

See Fitch, John T. AMCEE: A National Response to the Need for Continuing Education in the U.S. Paper presented at the First Andean Conference on Continuing Engineering Education. Caracus, Venezuela: May 28, 1980.

(62)

Baldwin, Lionel V. New Modes for Advanced Engineering Education. Engineering Education, 1983, 73 (5), pp. 384-385.

ENGINEERING CONTINUING EDUCATION PROGRAMS
OFFERED OFF-CAMPUS BY TELEVISION
NON-ACADEMIC CREDIT
1981-1982

Institution	Number of Locations	Total Courses	Total Enrollment
ACE (Stanford)	40	40	2,000
Auburn	1	6	413
Case Western Reserve	148	38	160
Colorado State	956	36	6,405
Georgia Tech.	40	16	90
Ill. Inst. of Tech.	11	6	74
Iowa State	N/A	1	612
MIT	1,200	30	30,000
No. Carolina State	5	8	445
Polytechnic Inst. NY	2	2	N/A
Purdue	13	19	1,063
Southern Methodist	16	75	60
Stanford	135	142	3,629
Univ. of Arizona	29	38	N/A
UCal Berkeley	6	24	724
UCal Davis	3	39	52
Univ. of Colorado	6	10	35
Univ. of Idaho	12	11	40
Univ. of Illinois	8	10	562
Univ. of Kentucky	29	2	91
Univ. of Maryland	10	75	450
Univ. of Massachusetts	13	13	260
Univ. of Michigan	10	24	250
Univ. of So. Cal.	21	67	2,252
Univ. of Wisconsin	23	30	856

(63)

Baldwin and Down, Educational Technology in Engineering, Washington, D. C., National Academy Press, 1981, pp. 31-33.

ACADEMIC CREDIT ENGINEERING GRADUATE PROGRAMS
OFFERED OFF-CAMPUS BY TELEVISION
AND GRADUATE DEGREES AWARDED TO DATE
(1981-1982)

Institutions (Start Date)	# Remote Locations	Total Courses	Total Enrollment	Degrees Awarded
ACE (Stanford) (1969)	40	21	1,000	350
Auburn University (1978)	1	8	16	N/A
Case Western Reserve (1972)	148	38	396	55
Colorado State (1967)	53	91	1,108	187
Cornell University (1973)	N/A	N/A	N/A	4
Georgia Tech. (1978)	40	32	382	N/A
Illinois Tech. (1976)	28	111	1,271	81
Iowa State (1969)	9	18	109	10
North Carolina State (1976)	5	11	112	N/A
Oklahoma State System (1972)	65	211	2,563	N/A
Purdue (1970)	21	13	376	200
RIT (1971)	N/A	N/A	N/A	51
Southern Methodist (1967)	32	67	1,143	471
Stanford (1967)	135	42	877	245
Univ. Alaska (1981)	2	3	102	N/A
Univ. of Arizona (1972)	12	42	320	N/A
UCal Davis (1970)	3	40	88	50
UCal Santa Barbara (1974)	2	30	68	114
Univ. of Colorado (1968)	22	8	92	4
Univ. of Florida (1964)	N/A	N/A	N/A	253

Univ. of Idaho (1975)	115	39	413	15
Univ. Illinois Urbana	N/A	N/A	N/A	9
Univ. of Maine (1972)	12	19	289	N/A
Univ. of Maryland	10	75	300	N/A
Univ. of Massachusetts (1975)	40	35	220	3
Univ. of Michigan (1970)	10	24	259	176
Univ. of Minnesota (1971)	18	77	1,040	65
Univ. of So. Carolina (1969)	77	39	510	421
Univ. of So. Cal. (1972)	22	111	1,333	525
Univ. of Tennessee (1967)	16	55	568	114
Univ. of Texas-Arl. (1981)	20	42	168	N/A
Univ. of Wisconsin (1970)	23	2	117	N/A

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Waniewicz, Ignacy, "Broadcasting for Adult Education: A Guidebook to World-Wide Experience, New York, UNIPUB, ERIC Document Reproduction Service No. ED 065 982), 1972, pp. 39-40, in Shanks and Hoccheimer, "Televised Instruction and Continuing Education of Engineers," 1982.

(65)

Gibbons, J. F. Tutored Videotape Instruction. Speech given before the Conference on Educational Applications of Satellites. Arlington, VA: February 2-3, 1977, p. 6.

(66)

Though considered a national model, the Stanford TVI Program has not gained unified acceptance throughout the School of Engineering's faculty. This is not uncommon throughout research-oriented institutions of higher education using TVI to support extended engineering education. Note the following:

> The use of communications technology for expanding the productivity of educators is apparent, but its application remains controversial. In many engineering departments, including Stanford's, resistance the use of broadcast classes is

> strong. Two fears stand out in the minds of many faculty. The first is that the rapid rise in numbers of "remote" students will pressure faculty to spend more and more time monitoring examinations and attending to the associated administrative work. When it comes to extending the participation of industry-based students in the degree-granting master's program, the resistance is even stronger. In the words of Engineering Dean William Kays, the Stanford faculty resistance may have more to do with tradition than with substance. "I think by nature," he states, "faculty are suspicious and resistant to 'volume'. They worry about the dilution of the Stanford name and reputation as courses are broadcast beyond the immediate at manageable boundaries of Silicon Valley. The fear is that at some point in time or in scale, the program no longer IS Stanford."

Botkin, 1982, pp. 136-137.

(67)

Gibbons, J. F., Kincheloe, W. R., and Down, K. S., "Tutored Video Instruction: A New Use of Electronics Media in Education," Science, Vol. 195, March, 1977, p. 1140.

(68)

Gibbons, J. F. Tutored Videotape Instruction, 1977, p. 5-6.

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Gibbons, Kincheloe, and Down, 1977, p. 1142.

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Tribus, Myron. Making the Most of the Differences in Objectives Between Academia and Industry. In Proceedings, AMCEE Workshop, World Conference on Continuing Engineering Education, Mexico City, ASEE, 1979, p. 371.

(71)

It should be noted with interest that Shanks, in a survey of engineers participating in videotaped engineering courses offered that they were evenly divided on the question of whether or not they would like an on-site tutor. Of those that did have the benefit of a tutor on site, this population was also evenly divided on the helpfulness of the tutor. See Shanks, Thomas E., 'Survey of Engineers Who Have Taken Candid Classroom Courses," in Hutchinson, Charles E.,

Towards Improved Candid Classroom ITV: Program Evaluation and Development Guidelines, Atlanta, Association for Media-Based Continuing Education for Engineers, National Science Foundation Contract No. SED 79-19041, p. G-8, 1982.

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Lemon, Judith. Television of Delivery of Continuing Education to High Technology Engineers: A Solution of the Problem of Updating in a Fast Changing Society. Unpublished. Palo Alto, CA: Stanford University, 1984, p. 8.

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Chu and Schramm. Learning from Television: What the Research Says. Washington, D. C.: National Association of Educational Broadcasters, 1967.

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Jones, Educational Technology, 1986.

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Shanks, Thomas E., and Hochheimer, John L. Televised Instruction and Continuing Education of Engineers: A Selected Review of the Literature Since 1967. Appendix B, in Hutchinson, Charles E. (Ed.). Towards Improved Candid Classroom Instructional Television: Program Evaluation and Development Guidelines, Atlanta: Association for Media-Based Continuing Education for Engineers, National Science Foundation Contract No. SED 79-19041, June, 1982, pp. B1-B2.

(77)
Gibbons, J. F. Tutored Video Instruction, February, 2-3, 1977, p. 4.

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Chu and Schramm, 1968, p. 100.

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Knepper, Christopher K. Technology and Teaching: Future Prospects. In Knepper, Christopher K. (Ed.). Expanding Learning through New Communications Technologies, New Directions for Teaching and Learning Series, No. 9, San Francisco: Jossey-Bass, March, 1982, p. 84.

(80)
Shanks and Hochheimer, 1982, p. B-15.

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Eyster, George W. ETV Utilization in Adult Education. Adult Leadership, 1976, p. 110.

(82)
Ibid.

(83)
Shanks and Hochheimer, 1982, p. B26.

(84)
Evans, Richard I. Resistance to Innovation in Higher Education. San Francisco: Jossey-Bass, 1969, pp. 2-3.

(85)
McCosh, R. B., personal conversation recorded in Baldwin and Down, 1981, p. 17.

(86)
See Evans, 1969, pp. 50-51.

(87)
Evans, 1969, p. 55.

In a survey of faculty at nine colleges and universities, faculty were asked how they defined "good" university-level teaching. Of 287 respondents, 63 (22%) thought that knowing the content area and keeping up with research was sufficient. Forty-three people, 15% of the sample, noted the need for a pleasant personality and having an interest in students. Thirty-six faculty, 13%, believed that the ability to inspire was key. Only 19% of the sample considered preparation and the use of appropriate teaching methods important.

(88)
Evans, 1969, p. 143.

(89)
Evans, 1969, p. 183.

(90)
Evans, 1969, p. 68.

(91)
Evans, 1969, p. 71.

(92)

Evans noted:

> "The majority of respondents noted that instructional television has no real academic status. Its use might well lead to mass mediocrity. If it were any good, universities with greater prestige . . . would have adopted it. It is doubtful, they thought, that a truly superior university would use it. Furthermore, instruction on television could not be compared with classroom instruction; it would only lower academic standards, commercialize education, and weaken it."

Evans, 1969, p. 73.

(93)

Some of Evans' respondents noted that teaching on ITV placed "considerable emphasis on the lecturer's personality, which must have certain qualifications that few possess. (One respondent remarked, 'I wouldn't be a good TV instructor,' and another said, 'Probably fine as long as I'm not involved.'"

Evans, 1969, p. 74-75.

(94)

Dean, Robert V., "The Candid Classroom-A Definition," in Hutchinson, Charles E., 1982, Appendix A, p. A1.

(95)

Jones, et al., "Educational Technology for Quality Engineering Education".

(96)

Dean, 1982, p. A8.

(97)

Dean, 1982, p. A2.

(98)

Shanks and Hoccheimer, "Televised Instruction and the Continuing Education of Engineers," p. B-27.

(99)

Schramm, W. _Quality in Instructional Television._ Honolulu, HI: University of Hawaii Press, 1972.

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Shanks, Thomas E, "Survey of Engineers Who Have Taken Candid Classroom Courses," pp. G5-G9.

(101)

Baldwin, Lionel V., "Status and Quality of Videobased Delivery Systems," Chicago, Paper delivered for the 1983 Annual Meeting of the Commission of Institutions of Higher Education, North Central Association of Schools and Colleges, March 23, 1983, p. 9.

(102)

Of parallel interest is the fact that all of the schools and colleges of engineering listed above have undergone examinations of their ITV programs as part of normal accreditation and reaccreditation activities. "No engineering college has reported any problem with these regional accreditation assessments due to ITV operations." See Baldwin, "Status and Quality of Videobased Delivery Systems,", 1983, p. 10.

(103)

One of the faculty's greatest complaints is that students do not finish assignments and/or courses on time. Although this is not unexpected due to employment factors involving travel and similar factors, anecdotal incidences at the University of Massachusetts offers evidence that the degree of tardiness in completion may well be controlled by the faculty. The more structured and demanding the faculty are, and the more rigorous they are in enforcing timelines, the more students will respond accordingly.

(104)

In order to ameliorate these concerns, corporate coordinators will often videotape the real-time lectures for subsequent playback. While increasing the remote location's viewing flexibility, the talk back advantage is cancelled. At this point, the real-time system is no different than the "traditional" tape delivery operation.

(105)

Decker, W. D. and Tilles, A. Continuing Education: A Growth Program in our Laboratory. Engineering Education, 61 (8), 1973, p. 907.

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Holman, Jack, Assistant Provost for Instructional Media, Southern Methodist University, personal conversation at meeting of Association for Media-Based Continuing Education for Engineers, Atlanta, September, 1984.

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Lemon, Judith. Stanford Instructional Television Program, personal conversation, College Industry Education Conference, San Diego, January, 1985.

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Rogers, James L., Director, Instructional Television Network, Case Western Reserve University, Cleveland. Case Western Reserve University's Instructional Television Network. In Grayson, Lawrence P., and Biedenbach, Joseph M., 1978, pp. 120-121.

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Jones, et. al., "Education Technology for Quality Engineering Personnel"

(110)
Baldwin and Down, 1981, 15-20.

(111)
Taveggia, Thomas C. and Hedley, Alan R. Teaching Really Matters or does It? <u>Engineering Education</u>, <u>62</u> (6), 1972, pp. 546-549.

(112)
Baldwin and Down, 1981, p. 15.

(113)
Thorn, Donald C., and Bundy, E. Wayne. An Experiment in Teaching via Television. <u>Engineering Education</u>, <u>60</u> (2), 1969, pp. 125-127.

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(115)
Salloway, N. Video at MIT: A Progress Report. Cambridge, MA: Center for Advanced Engineering Study, Massachusetts Institute of Technology, May, 1974.

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Kenyon, R., Dean of Engineering, Rochester Institute of Technologies, Rochester, N. Y., personal communication with the authors, noted in Baldwin and Down, 1981, p. 16.

(117)
Ibid.

(118)
See Britton, C. C., and Schweitzer, H. H. Freshman Engineering at Colorado State. <u>Engineering Education</u>, <u>65</u> (2), November, 1974, pp. 162-165.

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See Sjogren, D., et. al. Studies on the Use of Extramural Videopublished Materials in Continuing Education: Final Report. Colorado State University, Fort Collins, CO: August, 1976, National Science Foundation Contract No. HES 75-19854

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Stutzman, W. L. and Grigsby, L. L. A Multimedia Approach to Remote to Remote Classroom Instruction. Engineering Education, 1973, 64 (2), pp. 119-123.

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See Kriegel, Monroe. Application of Technology in Continuing Education. Engineering Education, 63 (6), 1973.

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Gibbons, et al., 1977.

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Gibbons, et al., 1977, p. 1142.

(126)

Gibbons, Kincheloe, and Down, "Off-Campus Higher Education Engineering Instruction Using Videotape: Final Report," Palo Alto, Stanford University, DHEW Contract #400-75-0038, June, 1976, p. 5.

(127)

Gibbons, et al., 1977, p. 1142.

(128)

Gibbons, et al., 1977, p. 1143.

(129)

Gibbons, et al., 1977, p. 1145.

(130)

Lemon, 1984, p. 13

(131)

For application of ITV to medical education, see for example: Sox, H. C. Jr., Martin, K. I., Higgins, M. C, and Hickam, D. H.. Tutored Videotape Instruction in Clinical Decision-Making. _Journal of Medical Education_, _59_ (3), 1984, pp. 188-195; Pohl, R., Lewis, R., Niccolini, R., and Rubinstein R. Teaching the Mental Status Examination: Comparison of Three Methods, _Journal of Medical Education_, _57_ (8), 1982, pp. 626-629; Chessell, G., Peterson J., Khir A., and Steele, M. Experience with Audiovisual Materials for Students Beginning Clinical Medicine. _Journal of Audio Visual Media in Medicine_, _3_, 1980, pp. 64-67; Kaufman, D. M. and Kaufman, R. G. Usefulness of Videotape Instruction in an Academic Department of Neurology. _Journal of Medical Education_, _58_ (6), 1983, pp. 474-478.

CHAPTER 4

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See Knowles, Malcolm S. _Modern Practice of Adult Education: Andragogy Versus Pedagogy_. New York: Association Press, 1970.

(133)

The drop-out rate is no doubt fostered by corporate tuition reimbursement policies which generally will not reimburse students for failed courses. In instances where students find themselves in academic difficulty, early withdrawals and drops are anxiously sought by students who wish to cut their financial losses.

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Gibbons, et al., 1977, p. 1145.

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