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AUTHOR Hazard, Francis E.; Danner, Charles H.
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ABSTRACT

A need existed to develop a graphic procedure to predict student success in 2-year engineering technology programs, based on ACT scores and high school grades. The study stemmed from the need to help students identify their chances of success, to help students clarify their goals, and to indicate needed institutional responses. Regression analysis determined how well college achievement correlated with a composite of high school grades and ACT scores. Records of 48 students from September 1970 through June 1973 provided the data. The analysis resulted in a coefficient of correlation of r = .85 to provide a fairly high predictive measure. The paper illustrates a reliable means of objectively predicting student success based on ACT scores and high school grades. (Author)

PREDICTING STUDENT ACHIEVEMENT IN TWO-YEAR ENGINEERING TECHNOLOGY PROGRAMS

Dr. Francis E. Hazard, Director
Kent State University, Tuscarawas Campus
New Philadelphia, Ohio 44663
(216) 364-5561

Charles H. Danner, Supervisor
Associate Degree Engineering Technology Programs
Kent State University, Tuscarawas Campus

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PREDICTING STUDENT ACHIEVEMENT IN
TWO-YEAR ENGINEERING TECHNOLOGY PROGRAMS

Introduction

Objective student achievement forecasting data in the two-year college setting have become increasingly desirable. Early prediction of student chances of success can be useful in counseling new admissions into remedial courses or into programs commensurate with their apparent aptitudes and ability. Some students are discouraged from programs where their chances of success appear to be minimal. Moreover, since significant numbers of new student applicants lack clearly defined goals while others lack adequate preparation for their academic program choices, an objective predictive technique can provide a useful tool for a career counseling program.

Predictive information is also helpful to the institutional program planning budgeting system in which high-cost ratios are accompanied by high attrition in specialized courses or degree programs.

Yet practitioners have recognized that the use of existing standardized tests frequently does not yield desired results and the tests are usually not available for specialized needs. This problem can be partially solved through the construction of local norms based on standardized test results and high school grades commonly available in student records.

The purpose of this paper is to report on a method of predicting student achievement in the first year of students in associate degree engineering technology programs. The two-year campus where the predictive model was developed with a graphic display, has employed an "open door" admissions policy. The American College Test is required for placement; however, entrance examinations have not been used. Furthermore, it was deemed less expensive and less time consuming if a predictive norm could be developed utilizing data commonly available from student records. Timeliness would be enhanced if the success potential of an applicant/counselee could be determined immediately upon receipt of college admissions data—without requiring additional testing.

From September 1970 through June 1973, longitudinal data were collected summarizing student achievement in mechanical and industrial engineering technology programs at the Kent State University Tuscarawas Campus. For purposes of this study, only full-time students who had graduated from high school within two prior years were included. Examination of high school preparation and American College Test scores indicated that students entering these programs were typical when compared to national norms.

Engineering technology students frequently lack adequate math-science preparation and/or clearly defined goals. Therefore to reduce their attrition, it is highly desirable to identify those students who require remedial work prior to entering basic engineering technology and related courses. Thus it was concluded that a discriminant method would be helpful in identifying students who could predictably be expected to encounter difficulty in achieving the minimum grade point average to succeed in the engineering technology programs.

Objectives

The purpose of the present investigation was the development of a discriminant analysis system for predicting student success in the first year of associate degree mechanical and industrial engineering technology programs at the Kent State University Tuscarawas Campus. It was desired that the model offer a graphic display which could be readily interpreted and understood by both student and counselor in predicting probability of success and that the objective model be based upon knowledge of high school grades and ACT scores.

A supporting objective was to examine engineering technology students' perceptions of their career and degree goals. Student Evaluations of the engineering technology programs as related to achievement was also examined in terms of how far students had moved toward their goals.

Theoretical Framework

The basis for this study was recognition of the need to help students identify their probability of success in associate degree engineering technology programs offered on a two year campus. Broad aims of the institution lie in its endeavor to provide the academic atmosphere, the human associations, and the discipline vital to the student's sound intellectual growth and character development. The various programs of curricular and extra curricular activities are designed to stimulate his curiosity, broaden his perspective, enrich his awareness, deepen his understanding, establish disciplined habits of thought, prepare him for a vocation, and help him realize his potential as an individual and as a responsible and informed member of society. Specific objectives of the Engineering Technology program at the Kent State Tuscarawas Campus are: to provide entering students with sufficient education in a two year program so that graduates can obtain meaningful and gainful employment, to meet the needs of society for trained engineering technicians at the associate degree level, and to permit graduates to enter programs leading to the bachelor of technology degree.

The extent to which students clarify and identify their personal career goals is generally assumed to be related to their motivation, persistence and ultimate academic success. The need for explicit early career counseling for engineering technology students was demonstrated in a survey of goals of 52 students conducted at the Kent State University Tuscarawas Campus in March of 1972. Two-thirds held a fairly clear perception of their career goal while one-fourth indicated that goals were still in formation. (See Figure 1.) Eighty-one percent of the students aspired to attain the associate degree. Their viewpoint of college (See Figure 2) indicated that eighty-three percent held a practical view of college as a means of earning more money, having a more interesting career or enjoying a better position in society. Only thirteen percent held a more idealistic view of college as providing something more intangible, such as the opportunity to live better rather than to make a better living.

The goals survey indicated that while a majority of students held a specific goal, a significant proportion were still forming their career goals and needed career counseling. The maintenance of a grade point average of 2.0 is an inherent student goal since it is a requirement for graduation.

Figure 1

Student Career and Degree Goals

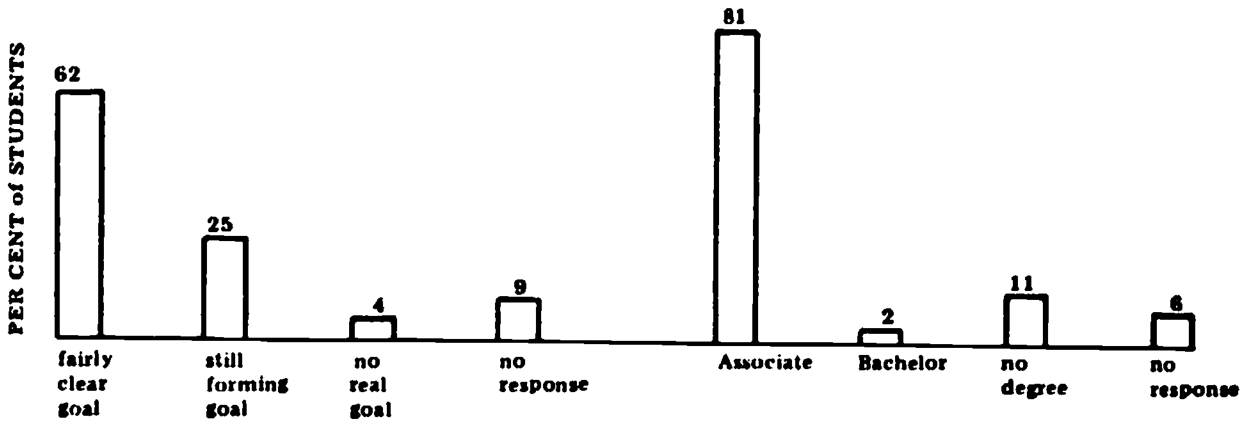
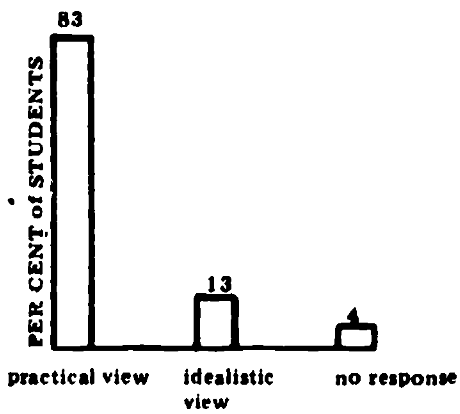


Figure 2

College Viewpoint



A more complete understanding of engineering technology students enrolled at the Kent State University Tuscarawas Campus may be found in the personal and background characteristics illustrated in Figure 3. Figure 3 summarizes proportions by age, employment, financial aid, veterans, and institutional choice. Academic preparation in terms of high school GPA and ACT distributions is illustrated in Figures 4 and 5. Approximately three-fourths of the students had a high school GPA between 2.0 and 3.0 while approximately two-thirds scored between 17 and 24 composite on the American College Test.

Figure 3

General Student Background Information

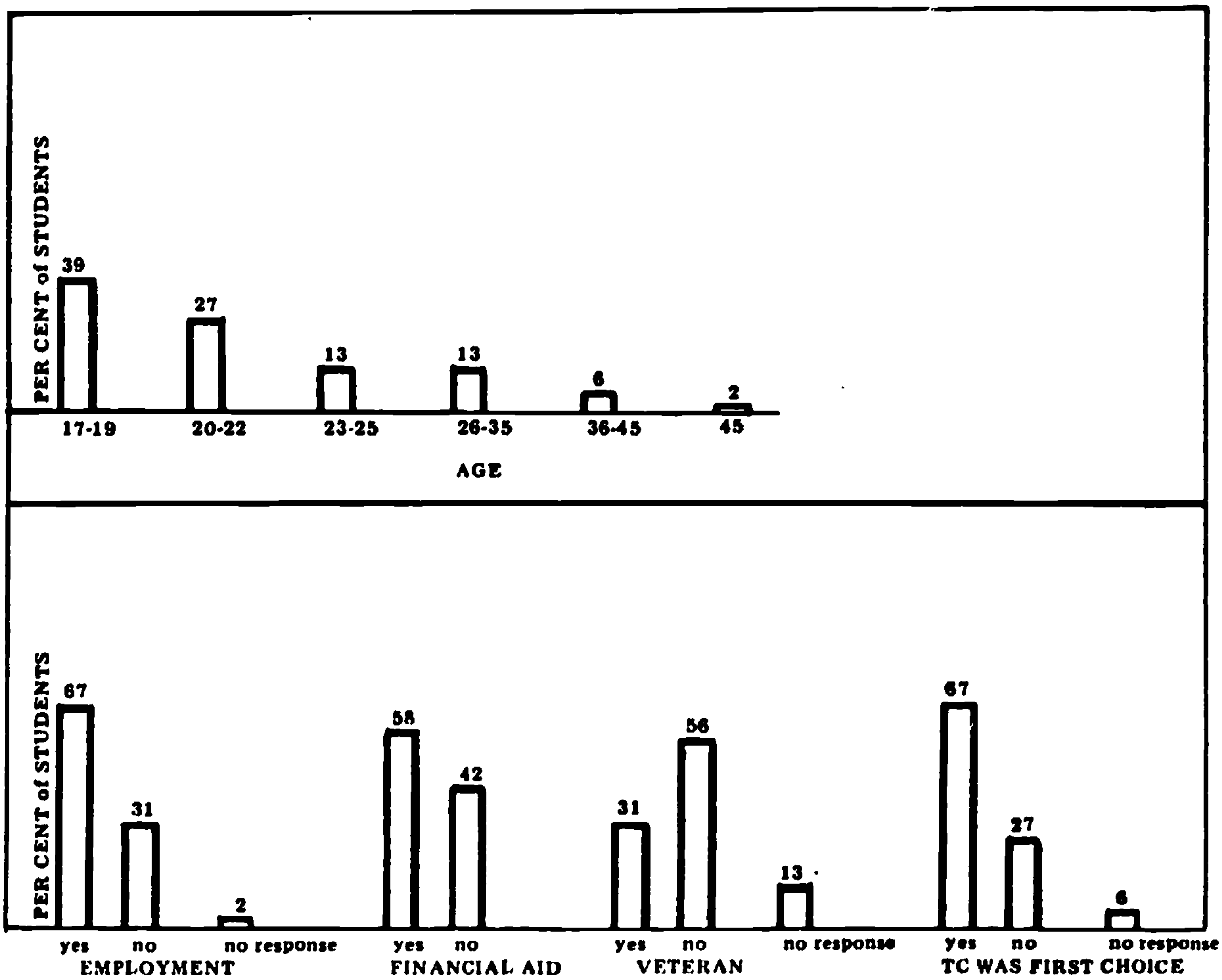


Figure 4

High School Grade Point Average Distribution

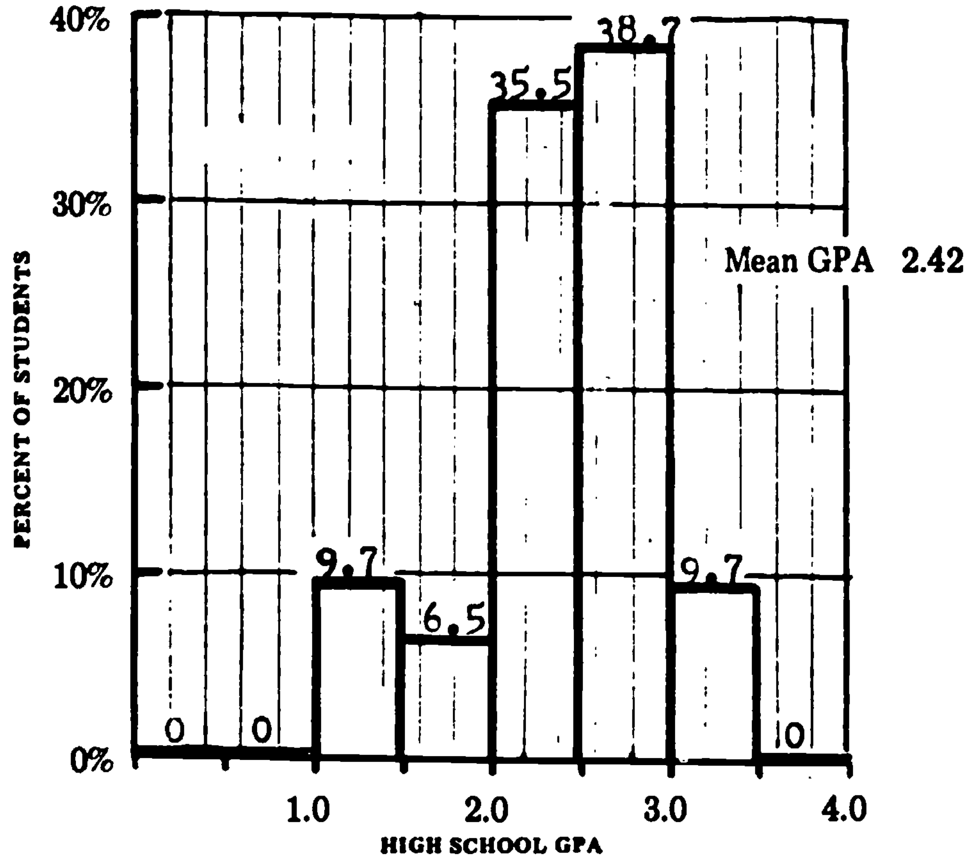
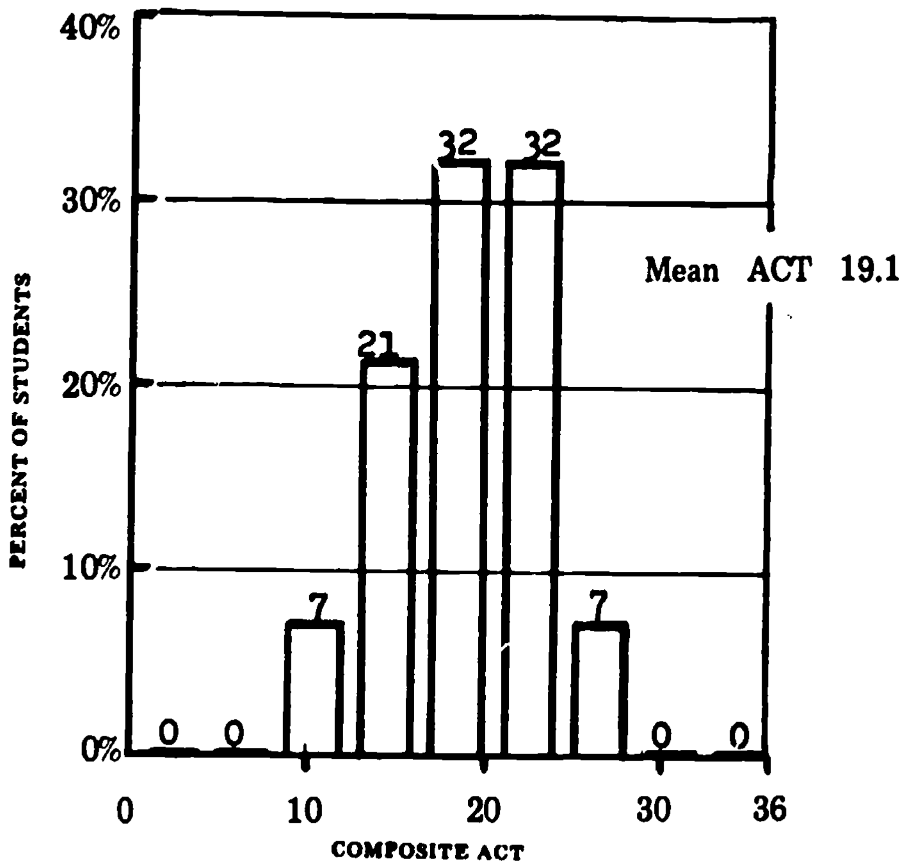


Figure 5

Composite ACT Score Distribution



A breakdown of ACT test results with national norm comparisons are shown in Table 1. Results indicate relatively high academic ability in math and natural science but relatively low ability in English and moderate ability in social science. It should be noted that while engineering technology students compare favorably with other students in two year colleges (based on composite ACT scores), they average significantly lower than baccalaureate bound engineering students (average ACT composite 25). This difference in ACT scores implies that in addition to differences in technical emphasis (Engineering: theoretical emphasis; Engineering Technology: practical emphasis) there appears to be a need for differences in teaching methods for engineering technology students such as: more demonstrations, more stress on basics and less on theory and detailed derivations.

Table 1

ACT Scores

ACT TEST	Student ACT Scores			National	
	Mean (Std. Dev.)	Percentile		Mean (Std. Dev.)	
		All Coll. Bound	2 year College	All College-Bound	2 year College
COMPOSITE	19.1 (4.4)	48	56	19.2 (5.4)	18.2 (4.8)
English	15.4 (4.8)	25	34	18.3 (5.2)	16.9 (5.0)
Math	21.1 (4.3)	63	73	18.7 (7.1)	17.6 (5.9)
Social Science	18.8 (6.5)	41	47	19.5 (6.6)	18.8 (6.2)
Natural Science	21.5 (5.2)	58	65	20.0 (6.4)	18.9 (6.0)

A comparison of the academic preparation of Kent State University Tuscarawas engineering technology students with a national sample of 1241 engineering technology students[2] is shown in Table 2. More specific high school curricular preparation for entering technology students is revealed by the percents having the technical subjects as shown in Figure 6.

Table 2

Comparison of High School Preparation of Tuscarawas Campus Students with National Sample

High School Quarter	Percent of Engineering Technology Students	
	National[1]	Tuscarawas Campus[2]
Highest Quarter	29%	21%
Second Quarter	41%	33%
Third Quarter	25%	33%
Lowest Quarter	5%	13%
High School Courses		
Mathematics	100%	100%
Physics	52%	30%
Chemistry	61%	43%
Drafting	56%	32%
Vocational Education	26%	67%

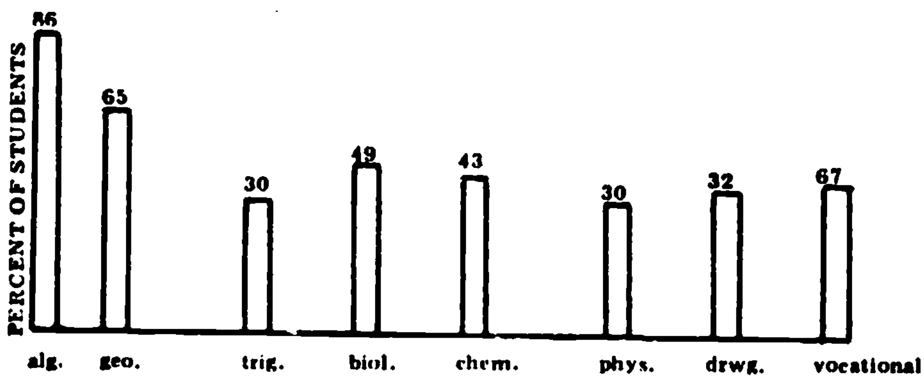
[1] Engineering Education, April 1971 [2] Quartile data: First and Second Classes; Course Data: First Class Only

Figure 6

High School Curriculums

Entering Engineering Technology Students

Tuscarawas Campus



Early experience with engineering technology students having academic problems in math or physics or both revealed that the problems were associated with poor math and science high school preparation. Therefore pre-technical math courses were initiated and students were counseled into them. Attrition studies had shown that students who were academically dismissed had significantly lower high school grade point averages and ACT averages (as a group) compared to those continuing in the program (as a group). Thus it was concluded that the extent of inadequate course preparation or background for engineering technology students held implications for institutional responses to the need for student learning improvement programs and services. Analysis of engineering technology student achievement, aptitude and other personal and background characteristics was also found to be implicit in the role of *teaching effectiveness* among various departmental faculty.

In retrospect, the above data suggested that the ability to predict the chances of student success in engineering technology programs would be an asset to the counseling staff, the student, the faculty, and the administration of the institution.

Sample Data

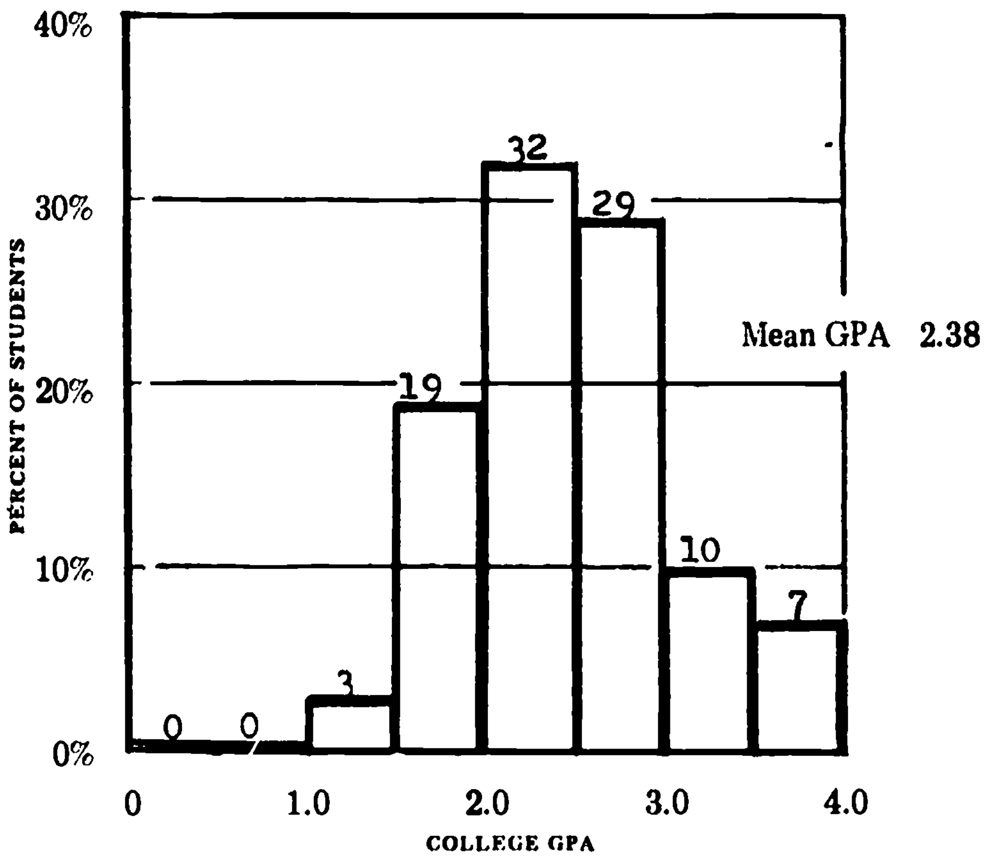
The population sample for this study consisted of 48 freshmen engineering technology full time students not more than two years out of high school. The predictive measures available for analysis were: high school grade point averages, specific high school course grades, ACT scores by academic areas and composite, and first year college GPAs.

The criterion of academic success selected in the engineering technology programs was the cumulative quality point ratio earned at the end of the freshman year by each student. A composite analysis of achievement in the engineering technology programs in Figure 7 illustrates the percent distribution of Kent State GPA for engineering technology students. A comparison of high school and college GPA distributions in Figures 4 and 7 suggested the possibility of a correlation between the two. The mean GPA was 2.38 while twenty-two percent had a GPA below 2.0.

College GPA achievement for Kent State Tuscarawas Campus Engineering Technology students was found to be 2.40, closely comparable to the national average of 2.461[2].

Figure 7

College GPA Distribution



Method of Analysis

Nomenclature.

GPA	College Grade point average (4.0 system)
HS GPA	High school grade point average (4.0 system)
ACT	Composite American College Test Score (36 maximum)

T	Technology number (range 0-100), a weighted average determined from HS GPA, ACT, ALG, GEO, ADM, and PHY
ALG	High school algebra average (4.0 system)
GEO	High school geometry average (4.0 system)
ADM	High school advanced math average (4.0 system, trigonometry, calculus, etc.)
PHY	High school physics average (4.0 system)
y	Dependent variable (GPA)
x	Independent variable
a	Regression equation slope
b	Regression equation y intercept
N	Sample size (no. of students)
r	Correlation coefficient (least squares method) Note: r = 0 implies no correlation r = 1 implies perfect correlation
SDy	Standard deviation of the y values (unbiased)
SEy	Standard error of estimate (of y value)
f	confidence band factor (from normal distribution tables)
Δ y	Maximum expected variation in y value for a given confidence level

Regression Analysis. The least squares method was used to determine the best linear equation relating college grade point averages with high school grades and ACT scores[3]. A small desk-top computer was programmed to give the best values for a and b and the correlation coefficient for the general equation, $y = ax + b$.

The dependent variable, y, was taken as the college grade point average upon completion of three quarters work for most students. Several students who achieved grade averages below 2.0 and did not complete three quarters are also included to extend the usefulness of the results into the low range of grade point averages.

The independent variable was taken as the high school grade point average, ACT score, or a weighted average referred to as the Technology Number (T).

Confidence Bands and Probability Graphs. Confidence bands on the graphs were determined to extend their usefulness in counseling new students. The bands were determined by using the standard error of estimate for each regression equation, SEy = (SD) ($\sqrt{1-r^2}$). The maximum expected variation in the y values is given by $\Delta y = (f)$ (SEy) where f can be determined from the normal distribution for any confidence level. The bands are determined by adding and subtracting Δy to y at any point along the line.

The probability graphs were constructed by determining the probabilities for success from the regression line and its confidence bands. The regression line and the 50 percent confidence band give three points which can be plotted on probability graph paper as a straight line. As a check, 95 percent confidence bands were also determined for the data presented here. Table 3 summarizes the procedure.

Table 3

Summary of Confidence Band and Probability Methods

Confidence Band*	% of Students Above Upper Line	% of Students Above Lower Line	f value
95%	2.5%	97.5%	2.0
50%	25.0%***	75.0%***	.68
0%**	50.0%***	50.0%***	0

Notes:

* % of students falling within band

** This is the regression line, 50% of students fall above and 50% below this line

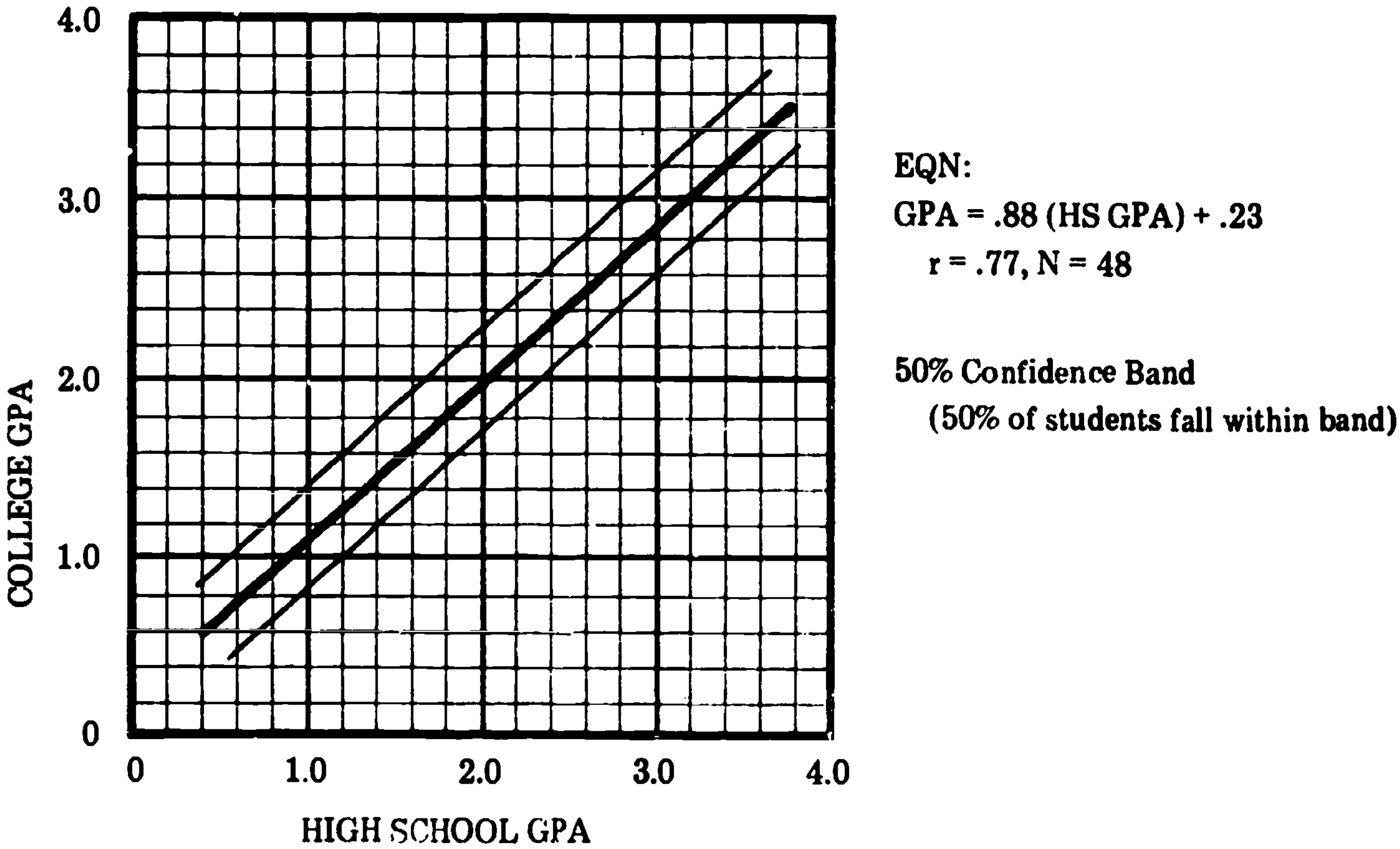
*** These percentages can be plotted vs. the independent variable (X) which is obtained from the intersection of the confidence band line with the dependent variable cut off (2.0 GPA used here since it is required for graduation).

Results of Analysis

Regression analysis revealed that the college GPA correlated relatively well with high school GPA. (See Figure 8.) The best linear relationship is GPA = .88 (HS GPA) + .23 with a correlation coefficient of r = 0.77. Note that the predicted college GPA of 2.0 corresponds approximately to a high school GPA of 2.0.

Figure 8

College GPA vs High School GPA for Engineering Technology Students

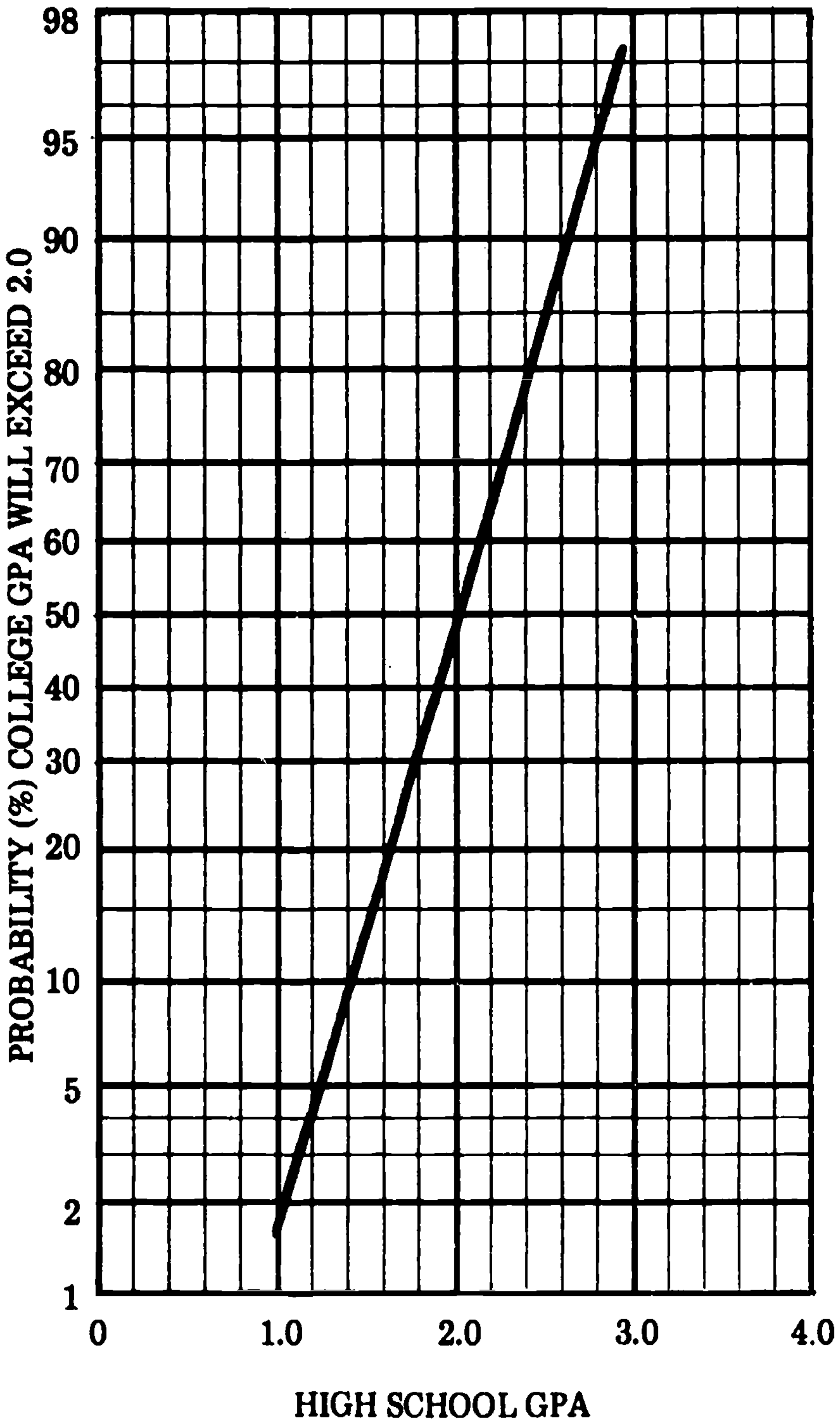


The graphic display, Figure 9, illustrates the probability that college GPA will exceed 2.0 based upon the high school GPA. For example, a student with a high school GPA of

1.6 holds about a 20 percent chance that his college GPA will exceed 2.0 (i.e., based on past student records, only one student in five achieved a 2.0 college GPA with a high school GPA as low as 1.6).

Figure 9

Probability College GPA Will Exceed 2.0 vs High School GPA

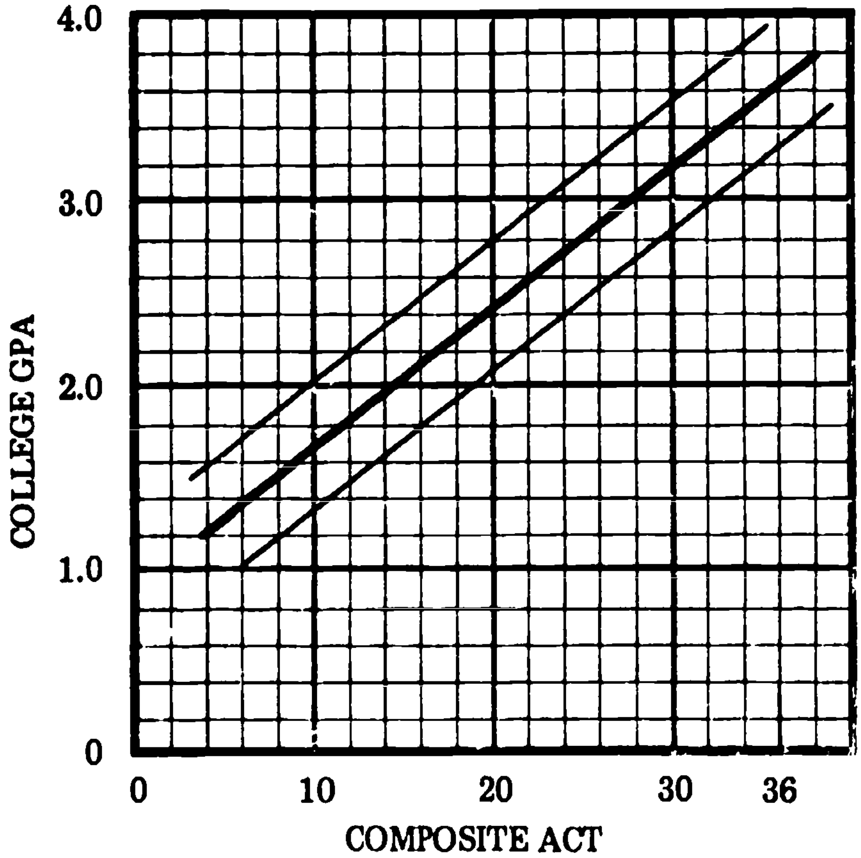


Intuitively one might expect that a student's maturity, years out of high school and life experiences would affect his performance in college. This was apparent in the examples of three veterans who achieved success in the engineering technology programs contrary to indications from their high school records. These results imply the need for caution in counseling students where individual differences and such factors as changes in goals or motivation can result in college achievement significantly better, or worse, than would be predicted from high school records. Based upon the above observation, only students who had graduated from high school within two years prior to college admission were included in the regression analyses of this study. Inclusion of other students resulted in significantly poorer correlation between high school and college GPA ($r = .41$ vs $r = .77$).

Moderate correlation was found between the college GPA and composite ACT scores. The linear relationship illustrated in Figure 10 is shown by GPA = .077 (ACT) + .91 with a correlation coefficient $r = .57$. It can be seen that the college level 2.0 corresponds to a composite ACT score of 15.

Figure 10

College GPA vs Composite ACT for Engineering Technology Students



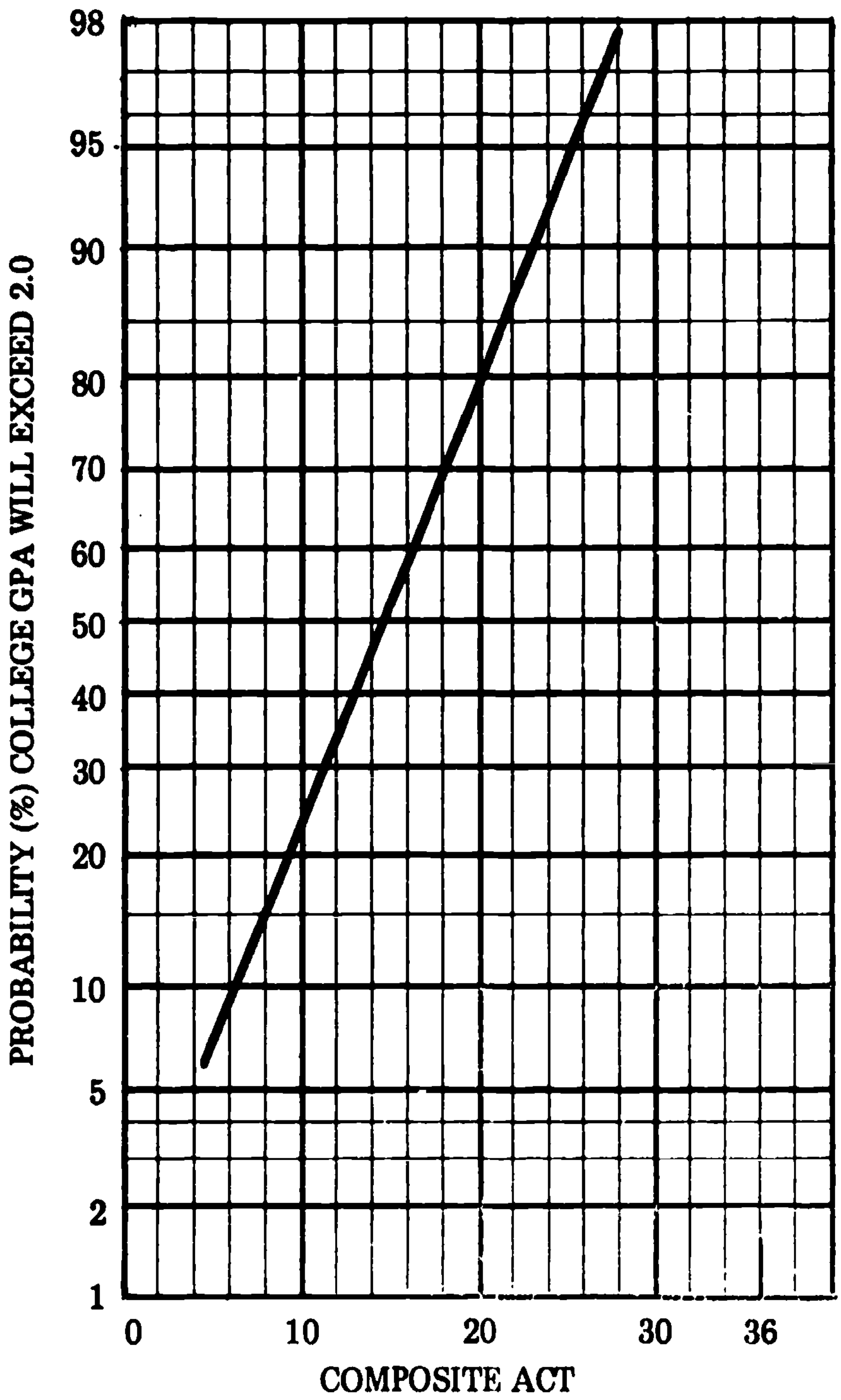
EQN:
GPA = .077 (ACT) + .91
r = .57, N = 41

50% Confidence Band
(50% of Students fall within band)

Figure 11 illustrates the probability that college GPA will exceed 2.0 for a given composite ACT score of a Kent State University Tuscarawas Campus engineering technology freshman. Correlations between college GPA and subject area ACT scores were much lower: Math ACT (r = .43) or natural science ACT (r = .54). This indicated that the composite score provides the most reliable indicator of success in the engineering technology programs.

Figure 11

Probability College GPA Will Exceed 2.0 vs Composite ACT



Academic counselors generally agree that the best indication of college achievement may be obtained by using both high school grades and standardized test results. For engineering technology, mathematics and physical science grades and test results are known to be especially important for predicting success.

There are many methods for combining grades and test results to use in predicting success. One method, generally referred to as stepwise linear regression, allows determination of the best coefficients ($A, B_1, B_2, B_3, \ldots$) for an equation of the form, $y = A + B_1 V_1 + B_2 V_2 + B_3 V_3 \ldots$ where $V_1, V_2, V_3, \ldots$ are the independent variables (grades or test scores). Ross[5], Morgan[4], Anderson, Weaver, and Wolfe[1], and Wick[6] use this method, reporting correlation coefficients ranging from 0.5 to .75, generally acceptable for predictive purposes.

A simpler method is to reduce several variables to one so that the general equation $y = ax + b$ can be used, allowing easy graphical analysis of the results. The single variable, x, can be obtained by weighting the individual grade or test score variables according to expected influence of each as follows:

$$x = \frac{w_1 v_1}{(v_1)\max} + \frac{w_2 v_2}{(v_2)\max} + \frac{w_3 v_3}{(v_3)\max} + \ldots$$

where $w_1, w_2, w_3, \ldots$ are the weightings (%) assigned to each variable, v. $(v)\max$ is the maximum possible score or points for each variable.

A single variable, referred to as the Technology Number, was determined using the following weightings and variables: ACT 25%, GPA 25%, Algebra 20%, Geometry 15%, Advanced Math 10%, Physics 5%. These weightings give the following equation:

$$T = .6944\,(ACT) + 6.25\,(GPA) + 5\,(ALG) + 3.75\,(GEO) + 2.5\,(ADM) + 1.25\,(PHY).$$

Theoretically, T could range from 0 to 100. For students included in the analysis, T ranged from 21 to 90.

Among the three regression analyses, the best coefficient of correlation was found utilizing the composite of ACT and high school grades. College GPA correlations with the Technology number, where the correlation coefficient r = .85, are shown by Figure 12. The best linear relationship is GPA = .035T + .62. The college GPA of 2.0 corresponds to T = 40. From Figure 13 one can determine the probability that college GPA will exceed 2.0 vs Technology Number, T scores.

Figure 12

College GPA vs Technology Number, T for Engineering Technology Students

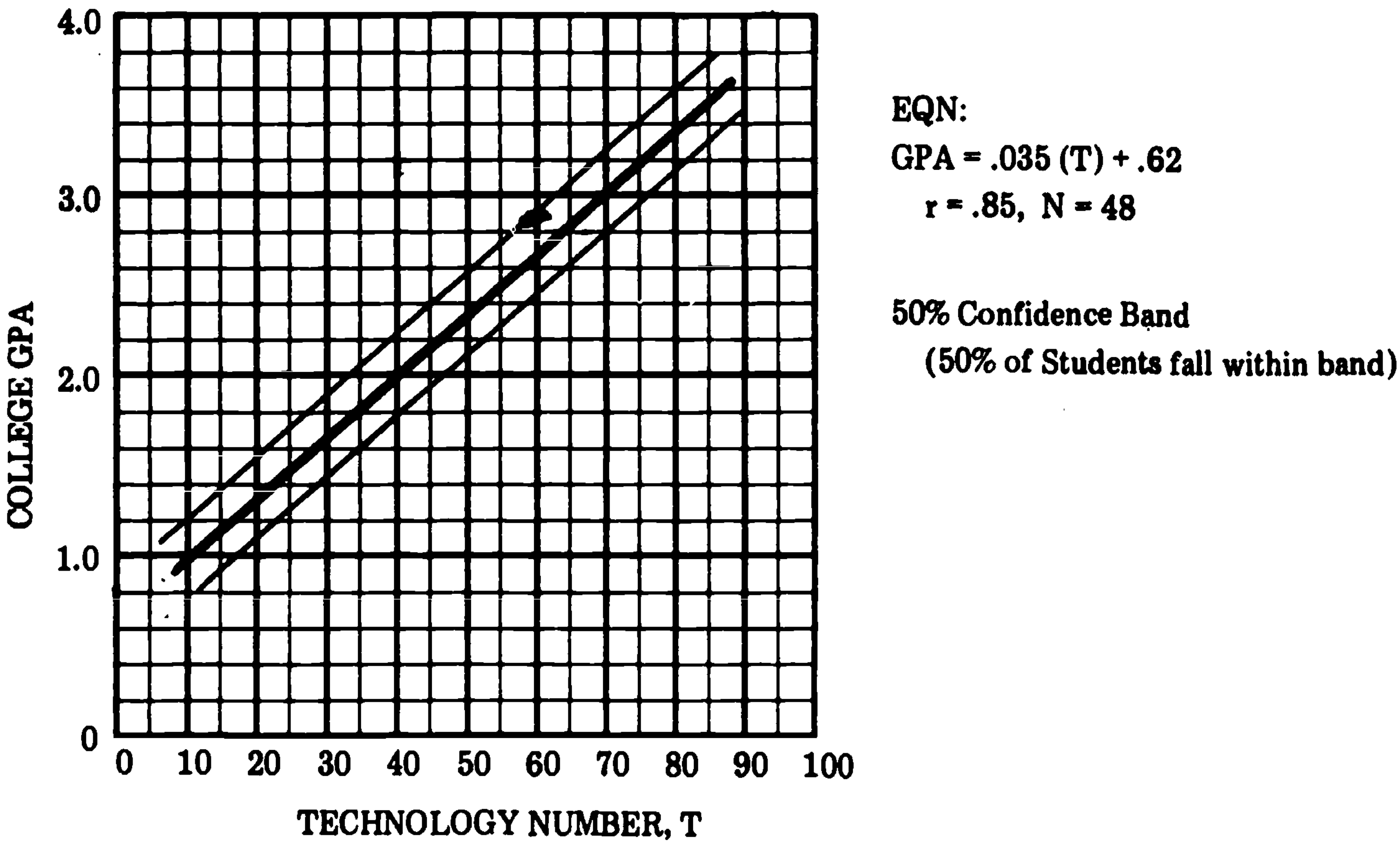
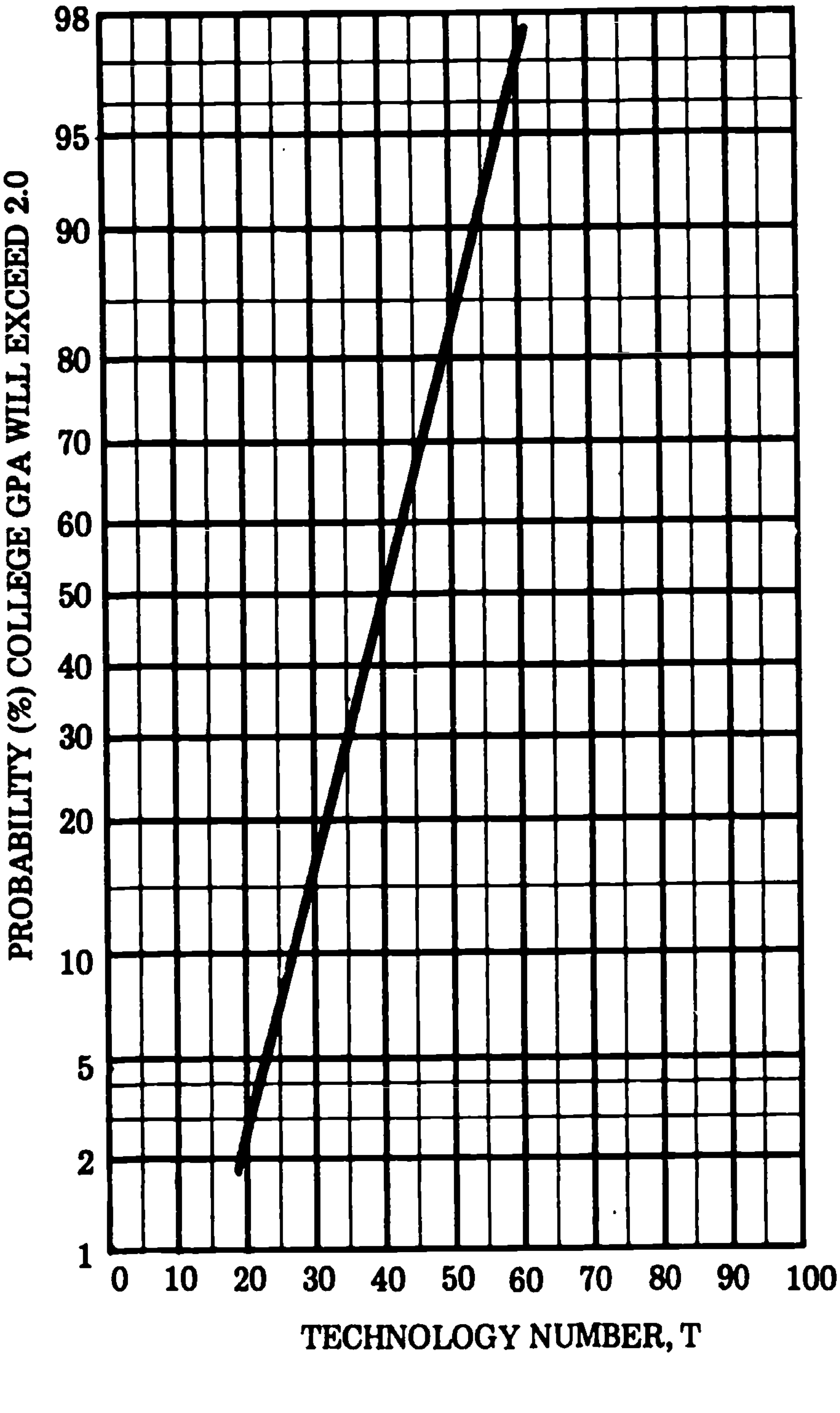


Figure 13

Probability College GPA Will Exceed 2.0 vs Technology Number, T



Application of Results and Conclusions

Table 4 summarizes the results of the regression analysis indicating that the Technology Number gives the best prediction of success.

Table 4

Summary of Regression Analysis

Figure	College Achievement Indicator	Equation for College GPA	Correlation Coefficient, (r)	Standard Error of Estimate (SE)*	Sample Size
8	High School GPA	GPA = .88 (HS GPA) + .23	.77	.41	48
10	Composite ACT	GPA = .077 (ACT) + .91	.57	.49	41
12	Technology No, T	GPA = .035T + .62	.85	.35	48

*Two-thirds of actual GPA's should fall within 1 SE of predicted value.

Table 5 shows the high accuracy of prediction obtained from the Technology Number for 17 students who entered in the Fall of 1972.

It may be concluded that the composite variable regression analysis technique can provide a useful device for objectively predicting the probability of success of new applicants in engineering technology programs based upon ACT scores and high school grades. The model presented in this study, with its graphic display, has the advantage of being readily

Table 5

Estimated College GPA foı 17 Engineering Technology Students

Student No.	COLLEGE GPA Predicted From T (1)	Actual (2)	Difference (1) − (2)
1	2.4	2.1	+.3
2	3.5	3.7	−.2
3	2.4	2.5	−.1
4	1.6	1.8	−.2
5	1.7	1.6	+.1
6	1.9	1.9	0
7	2.5	2.2	+.3
8	2.7	3.0	−.3
9	2.9	3.2	−.3
10	2.7	3.0	−.3
11	2.1	1.7	+.4
12	2.7	2.8	−.1
13	3.7	3.4	−.3
14	3.0	2.6	+.4
15	2.0	1.5	+.5
16	3.2	3.3	−.1
17	1.3	1.1	+.2

understood and interpreted by counselors, faculty and students. Use of data from this study resulted in an improved counseling program coupled with a learning improvement program of preparatory and remedial studies at the Kent State Tuscarawas Campus. Student retention was increased and attrition was significantly reduced. Engineering technology students as a group indicated significant progress in moving toward desired academic goals. Increased institutional emphasis has been given to career counseling for the benefit of students in the developmental stages of goal formation.

Implications

Use of an objective predictive system affords the counselor the advantages of (a) helping aspiring students to develop a more realistic perception of their chances of success in engineering technology programs, and (b) helping to identify subject areas of potential difficulty where a student lacks sufficient background preparation in related subjects. Such information can provide direction for the institution seeking to respond to student needs for learning improvement programs and services. Furthermore, because the cost-per-student in engineering technology programs is high, it is incumbent upon the institution to make proper assessment of a student's potential before advising him to enter a program—both for the benefit of the institution and for the individual student. The study demonstrates the feasibility of accurately predicting student achievement in specialized high cost programs and can readily be linked to program planning budget systems. It also provides a means for exercising a refinement of institutional accountability in response to the need for providing professional guidance services based upon objective research data. The model may be readily duplicated by others. Finally, it has the functional advantage of feasibility through utilization of commonly available data without additional testing.

A side benefit of this study was the implication for faculty development which indicated that student achievement is greatly enhanced by faculty who have strong preparation, occupational experience in their subject area and an empathetic understanding of the philosophy and goals of technical education.

Additional research should be conducted to assess the impact of academic predictive counseling information upon the morale and motivation of students as well as its impact upon their decisions about entering or leaving an academic program. Further study should also be made to compare the validity of the graphic predictive technique developed in this study with the stepwise linear regression technique utilized by researchers in other studies. Results of this study could also be tested for application to other academic programs.

Since evaluation of engineering technology programs and student achievement is seen as a continuing process, it follows that longitudinal followup studies should be made of the graduates' performances on their jobs and assessment of their career goals periodically after graduation.

Summary

A need existed for objective prediction of student achievement in the associate degree engineering technology programs of the Kent State University Tuscarawas Campus. The survival-attrition rate together with the fact that more than one fourth of the students lacked clear goal concepts and many were not adequately prepared gave stimulus to the study.

The primary purpose of the present investigation was to perform a correlation of college grades with high school grades and American College Test Scores that could be illustrated by graphic display for the prediction of the probability of success of aspiring new students in engineering technology programs. A regression analysis included six predictive measures: ACT, GPA, and high school grades in Algebra, Geometry, Advanced Math, and Physics. The equation resulted in a fairly high predictive measure with a coefficient of correlation of $r = .85$.

References

1. Anderson, G. R., C. T. Weaver, and C. T. Wolf. "Large Group Instruction in Elementary College Mathematics." American Mathematical College Monthly, 72 (1965), 179 - 181.

2. Defore, Jesse J. "Characteristics of Engineering Technology Students." Engineering Education, 61 (1971), 844 - 846.

3. Garrett, Henry E., and R. S. Woodworth. Statistics in Psychology and Education. New York: David McKay Co., 1970.

4. Morgan, William P. "Prediction of Success in Junior College Mathematics." Mathematics Teacher, 63 (1970), 260 - 263.

5. Ross, Louis. "Forecasting the Academic Achievement of Engineering Freshmen." Journal of Educational Research, 64 (1971), 307 - 310.

6. Wick, Marshall E. "A Study of the Factors Associated with Success in First Year College Mathematics." Mathematics Teacher, 58 (1965), 642 - 648.