THE RELATIONSHIP BETWEEN SUCCESS IN ACADEMIC SUBJECTS AND SUCCESS IN SHOP WORK AMONG STUDENTS AT TUCSON SENIOR HIGH SCHOOL

by

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A Thesis

submitted to the faculty of the

Department of Education

in partial fulfilment of the requirements for the degree of

MASTER OF ARTS

in the Graduate College, University of Arizona

1950

Approved: _____, _____
Director of Thesis Date

5-23-50

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NEED FOR THIS RESEARCH

There seems to be a feeling among shop teachers throughout our nation that the quality of the work done in their shops would be greatly improved if they could have students of greater academic or mental ability. Therefore, the purpose of this study is to determine the relationship, or correlation, between success in academic subjects and success in shop work. It will be assumed in this study that the degree of success in either type of school work is indicated by the mark awarded to the student, the greatest degree of success being represented by a mark of "1," and the least by a mark of "5."

An auxiliary purpose of the study is to determine the relationship between I.Q. and success in shop work.

The question arises, what is meant by shop work and by academic subjects. In this study, the following are included under shop work: Auto mechanics, aircraft engine mechanics, drafting, electric shop work, graphic arts, general metal work, and woodwork.

On the other hand, the academic subjects involved here are: English, foreign languages, mathematics, social science, commercial courses, and science. A further breakdown of the courses comprising these subjects for which scores were collected is presented in Table I.

TABLE I

Courses Comprising Main Fields of Study

SHOP COURSES						
Drafting	Graphic Arts	General Metal Work	Woodwork	Auto Mechanics	Aircraft Eng.Mechanics	Electric Shop Work
Mechanical Drawing Architectural Drawing	Printing Linotype Photography	Welding Sheet Metal Work Machine Shop	Elementary Woodwork Advanced Woodwork	Vocational Auto Mechanics	Vocational Aircraft Mechanics	Elementary Electrical Work

ACADEMIC COURSES					
English	Foreign Languages	Mathematics	Social Science	Commercial Courses	Science
English 3,4,5, 6,7,8 Public Speaking	Spanish Latin French	Algebra Geometry Trigonometry Solid Geometry Business Arithmetic Economic Mathematics	American History Early European History World History Latin-American History	Typing Shorthand Bookkeeping Elementary Sales Advanced Sales Commercial Law	Biology Physics Chemistry

The marks used in this problem are those for the first semester of the school year 1948-1949 and were collected directly from the permanent record file in the registrar's office of the Tucson Senior High School. The complete records of all those students taking shop work were found and copied, one card being used for each student. In addition to the marks in the subjects mentioned above, the scores on the American Psychological Examination were recorded.

A large majority of students taking shop work were boys; however, in drafting and graphic arts there were quite a number of girls. The greatest number of shop students came from the ranks of the sophomore class, and somewhat smaller groups from the junior and senior classes. Since Tucson Public Schools operate on a 6-3-3 system, there is no freshman class in the senior high school.

DISTRIBUTIONS, THEIR CENTRAL TENDENCY, AND VARIABILITY

The obtained scores were grouped into frequency distributions for the American Psychological Examination, and for each of the subjects previously mentioned. The mean, median, and standard deviation for each were then calculated. As a check on the divergence from normality of the separate distributions, the formula $Sk = \frac{3(\text{Mean}-\text{Median})}{\text{Std.Deviation}}$ was applied to each as a comparative measure of skewness. Table II presents a summary of these measures.

TABLE II

A Summary of Central Tendency, Variability and Skewness
(Raw Scores)

Subject	Number of Shop Students Enrolled	Mean	Median	σ	Skewness $3\ (\frac{M-Mdn}{\sigma})$
English	471	3.31	3.33	.81	.07
Science	187	3.24	3.26	.86	.07
Commercial Courses	105	3.07	3.04	1.08	-.08
Social Sciences	243	3.26	3.27	.82	.04
Mathematics	107	3.02	3.06	1.22	.09
Foreign Languages	83	3.27	3.47	1.1	.54
Shop	480	2.55	2.52	.9	-.10
I.Q. (American Psych. Exam.)	472	76.2	73.0	20.9	.45

The marking system used in this school consists of the numbers 1,2,3,4, and 5; the number 1 being the most desirable and the number 5 denoting the poorest work, a failure. It might be expected that in a fairly large sample the mean, or average would fall on or very near the mark of 3. Table II, however, shows the shop mean to be considerably above this point, and all of the academic means below it.

These questions immediately arise: are the shop instructors "easy graders", or is the work actually easier than academic work for the average student? Or, do those who take

it have a greater interest in the work than do those who take academic work? The variability of the shop scores, indicated by a standard deviation of .9, while not the least, is only slightly greater than the smallest. This standard deviation of .9 indicates that the middle 68 per cent of the shop marks lie within ± .9 from the mean, or between 1.7 and 3.5, while, for comparison, 68 per cent of the English marks lie between 2.5 and 4.1.

It is interesting to note from Table II that the greatest degree of skewness occurs in the field where the smallest number of students is involved, namely, foreign languages. This may possibly indicate that the sample was too small. All of the other distributions are approximately normal with the exception of the I.Q. spread, in which slightly significant skewness is found.

It might be well at this point to recall that positive skewness indicates a piling up of low grades, whereas a negative skewness indicates a piling up of high grades. It is to be expected that negative skewness would appear in the shop distribution, because of the high average. All except one of the other subjects show positive skewness. This seems to suggest that the academic work is more difficult, or that the teachers of those subjects are hard graders.

CONVERSION OF MARKS TO Z-SCORES

After the measures of central tendency and variability had been calculated, and it was found that normality could

reasonably be assumed for all of the distributions, it was necessary to convert the marks in all the subjects into comparable scores before correlating them. Conversion of marks into comparable scores is required because of the variation in difficulty among the different subjects and the differences in marking standards among the teachers. In this study, z-scores were used. By the use of zeta scores, it was made possible to average all the academic marks of each student in order to obtain one composite score to correlate with the shop score, and to average the shop scores for those students taking more than one shop course.

In Table III, a summary of the z-scores is shown. These scores are actually the marks given by the teachers converted to a ten-sigma distribution in which the mean is 50, the standard deviation is 10, and zero is at 5 sigma below the mean.

Table III

Marks Awarded by Teachers and Their Equivalent Z-Scores.

Subject	Marks Awarded by Teachers				
	1	2	3	4	5
	z-score	z-score	z-score	z-score	z-score
English	79	66	54	42	29
Science	76	64	53	41	30
Commercial Courses	69	60	56	41	32
Social Science	78	65	53	41	29
Mathematics	67	58	50	42	34
Foreign Languages	71	62	52	43	34
Shop	67	56	45	34	23

It is therefore easily seen in Table III that a "1" in English (z-score of 79) represents a considerably greater degree of achievement than a "1" (z-score 67) in shop. Likewise, a score of "5" in English (29) represents better work than a score of "5" in shop (23).

On that basis, however, it would appear that it is as easy for shop students to get a mark of "1" (67) in mathematics as it is to get a "1" (67) in shop. This may be partially explained by referring to Table II. There it can be seen that less than one-fourth of the shop students were taking mathematics. The mean I.Q. for this group was found to be 79.2, a somewhat higher average than that of the shop students as a whole. This should partially account for the achievement in mathematics. Another factor which may be involved here is the fact that mathematics may be more objectively marked than other subjects. Since among the subjects mathematics showed the highest variability, the variability of the I.Q. scores of the shop students taking mathematics was checked and found to be 21.3, again somewhat higher than that of the whole group, and no doubt a factor in the greater spread in mathematics scores.

CORRELATIONS

Correlations were calculated between the scores of the several academic subjects and the shop scores, between the composite academic scores and the shop scores, and between the I.Q.'s and the shop scores. In these correlations the zeta scores were used. A summary of these correlations and their probable errors is given in Table IV.

Table IV
Summary of Coefficients of Correlation (r)

Courses	r	Probable Error of r	Remarks
English & Shop	.34	.03	Low correlation
Science & Shop	.35	.04	Low correlation
Commercial Courses and Shop	.31	.06	Low correlation
Social Science and Shop	.31	.04	Low correlation
Mathematics and Shop	.12	.06	Insignificant correlation
Foreign Languages and Shop	.47	.06	Substantial relationship
All Academic Subjects & Shop	.37	.03	Low correlation
I.Q. and Shop	.35	.02	Low correlation

It might be well at this point to review the meaning of correlation. There is sometimes a definite relationship between one factor and another, or one ability and another. This relationship may be either negative or positive, strong or insignificant. Our purpose here is to discover that relationship, if any, between success in shop work and in academic subjects, and between shop success and the score on an intelligence test. The coefficient of correlation expresses the degree of association of the two factors being compared. When the relationship is perfect, the coefficient of correlation is "1". For example, in a perfect correlation, if

one of our shop students received a mark of "1" in English, we could expect him to receive a high mark in shop work. On the other hand, if the correlation were ".00", we could not predict any particular shop mark or the reverse.

Table IV shows that in one instance, mathematics, the correlation with the shop scores is insignificant, since to be significant a coefficient of correlation must be more than four times as large as its probable error. With the r of .12 in mathematics, and a P.E. of .06, the chances are only 82 to 18 that the correlation will be positive. Since there are thus 18 chances in 100 that the true r in this case is negative, the obtained r is clearly insignificant. The relationship of the success in all of the other subjects with success in shop work proved to be low, with the exception of foreign languages, in which a more marked correlation was found. It is possible that this higher relationship might be explained in the following manner. Many of the shop students of Tucson Senior High School are from Spanish speaking homes and have a definite language problem. When these students register for a foreign language they usually choose Spanish, and in this subject are not particularly hampered by their language difficulty.

Correspondingly, in shop work they are not held back greatly by their lack of ability in English because a high percentage of the success in the shop depends upon hand skill.

The two correlations shown in Table IV which are possibly

the most meaningful, namely between all academic subjects and shop, and I.Q. and shop, show that positive relationship is present, but slight. This explains why the predictions made later in this report are of relatively little value.

As an interesting check on the extreme cases in the study, and as further explanation of the low correlation, the academic average for the 50 (approx.) students having the highest shop grades, was calculated, and also the academic average for the 50 (approx.) having the lowest shop scores. Conversely, the shop average was found for the 50 who were best, and for a like number who were poorest in their academic work. A summary of these findings follows:

The 58 students with marks of "1" in shop work averaged only "2.37" in all their academic work, while the 53 students who averaged "4.04" in shop work average "3.70" in academic subjects.

The 50 shop students with an average of "1.81" in academic subjects averaged "1.78" in shop work, and the 47 who averaged "4.37" in academic work received an average of "3.01" in the shop courses. In three of these four comparisons, the shop mark is higher than the academic mark, as would be expected in the light of previous findings. Since the sample in each case is less than one-ninth of the whole group, its small size may be the cause of this irregularity.

There is concrete evidence in the above figures that the relationship between success in the two fields is low,

bearing out the findings presented in Table IV. These figures would also seem to indicate, as did Tables II and III, that it is easier to earn a high mark in the shop than in academic work, since the best academic students earned an average of "1.78" in shop, while only "2.37" in academic subjects was averaged by those who were best in the shop. And, at the other extreme, those who were poorest in academic work averaged "3.01" in the shop as against the "3.70" academic average of the poorest shop students. It must be remembered while reading the above statements that we are speaking of marks awarded by teachers, not relative achievement. For the relative achievement indicated by these marks we must refer to Table III, where, for example, it can be seen that a "2" in English represents achievement almost equal to a "1" in shop.

PREDICTIONS

The predictions in which the author was most interested were estimated shop marks predicted from academic marks. Regression equations were calculated from each correlation and predictions made, using the deviation form of the equation. In this method, the distance from the mean is found for the mark from which a prediction is to be made. Then, the most probable distance from its own mean is calculated for the mark to be predicted. This distance which the predicted mark lies from its mean is controlled by the size of the correlation coefficient, the difference, if any, between

the two means and the relative variability. Moreover, in estimating the most probable shop marks from certain academic marks or I.Q. scores, the low coefficients of correlation cause the probable error of estimate to be high and the predictions to be highly unreliable.

Table V gives some of the most interesting estimated shop marks in z-scores, and their probable errors (P.E.est.). For example, if a counselor or teacher wished to estimate the probable shop success of a student who had earned a zeta score of 37 (4) in English, he would find 45 (3) to be the most probable score this person would receive in shop work.

Table V

Predicted Shop Scores and Their Probable Errors

Subject	Zeta Score	Shop Z-Score	P.E. Est.	Raw Score
English	79	61	6.15	1.56
English	37	45	6.15	3.00
All academic subjects	52	51	6.03	2.46
All academic subjects	31	42	6.03	3.27
I.Q. (American Psych.Exam.)	38	46	6.24	2.90
I.Q.	52	51	6.24	2.46
I.Q.	76	56	6.24	2.01

However, the high probable error of 6.15 indicates that there is a 50-50 chance that the true shop zeta score will lie

between 38.85 and 51.15 (45 ± 6.15).and we can only be sure that the true shop mark lies within 45 ± 4 X 6.15, or between 20.40 and 69.60. In contrast, note the prediction made from a zeta score of 79 (1) in English. Although it has been shown in Table III that a "1" in English represents greater achievement than a corresponding mark in shop work, it is only possible to predict a shop score of 61 (1.56) for a person who does the highest quality of work in English. This is, of course, due to the low relation between success in the two subjects.

From the evidence in Table V, we must assume that it cannot safely be said that one person will have notably greater success in the shop than another person because the first is doing better academic work, or has a higher I.Q. score, even though the trend is in that direction. This is borne out by the three predictions made from I.Q. scores.

COMPARISON WITH SAMPLE GROUP

While gathering the data for this study, it seemed likely to the writer that valuable information might be gleaned by comparing the I.Q. and success in academic work of the shop students with that of another group of the same size who did not take shop. Accordingly, as the record of each shop pupil was copied, the card was turned over, and on the back was copied the marks of the next person in the file who was of the same sex but did not take any shop work. This furnished a random sample of the non-shop students of the high school.

Since there were, at the time of the collection of these data, approximately 2470 persons listed in the active record file of the school, and 480 of these were enrolled in shop courses, the sample group amounted to almost 480 out of the 1990 not taking any shop work.

Distributions were made of the academic marks of this group and the mean and standard deviation calculated for each of the subjects listed in Table I.

In order to discover whether the shop group ranked above or below the sample group in any one academic subject, it was necessary to find the difference between the means of the two groups in that subject and then calculate the standard error of that difference. The same procedure applied to the variability or standard deviation. Table VI summarizes the comparison of the means in the various academic subjects, and Table VII shows the same material in relation to the standard deviations.

Table VI

Comparison of Means and the Significance of their Differences

Subjects	Means		Difference $(M_1 - M_2)$	σ_{D_M}	Remarks
	Shop Group	Sample Group			
English	3.3	2.83	.47	.06	Significant dif.
Science	3.24	2.72	.52	.09	" "
Commercial	3.06	2.64	.42	.13	" "
Soc.Science	3.26	2.63	.63	.08	" "
Mathematics	3.02	2.84	.18	.13	Insignificant dif.
Foreign Langs.	3.27	2.93	.34	.14	" "
I.Q.	76.2	85.1	8.9	1.39	Significant dif.

In each case when the standard error of the differences (σ_{D_M} or σ_{D_σ}) had been found, that difference could be declared significant if it was greater than three times its standard error. Taking English for example from Table VI, we see that the difference between the two means is .47, while its standard error (σ_{D_M}) is only .06. This shows that the true difference between these two means is significant. Thus, it is clear that the sample group ranks significantly higher than the shop students in English. This is also true of the I.Q. and of all the other subjects, with the exception of mathematics and foreign language, where the differences between the means are not significant, that is, there is some chance that the means of the shop group rank above those of the sample group in these subjects.

Table VII

Comparison of Standard Deviations (σ) and the Significance of their Differences

Subjects	σ Shop Group	σ Sample Group	Difference $(\sigma_1 - \sigma_2)$	σ_{D_σ}	Remarks
English	.81	.85	.04	.04	Insignificant dif.
Commercial Courses	1.08	1.11	.03	.09	" "
Science	.86	.97	.11	.06	" "
Social Science	.82	1.0	.18	.06	Significant "
Mathematics	1.22	1.0	.22	.09	Insignificant "
Foreign Lang.	1.1	1.08	.02	.10	" "
I.Q.	20.9	.9	.9	.98	" "

A glance at Table VII shows the variability of the sample group, as indicated by the standard deviations (σ's), to be greater than that of the shop group in all except two subjects, mathematics and foreign languages. These are the same two subjects in which the sample group does not significantly outrank the shop group as shown in Table VI. However, the differences in variability are so slight as to be insignificant in all except one subject, social science. Again, as in the case of the means, the significance of the differences is indicated by the relative size of the standard errors (σ_{D_σ}) of the differences. To be significant, the difference ($\sigma_1 - \sigma_2$) must be at least three times as large as its standard error.

COMPARISON WITH AVERAGES IN STATE'S LARGEST SCHOOLS

To get a better idea as to whether the achievement of our sample group is a fair basis on which to judge the academic ability of the 480 shop students, let us compare the averages of both groups with those found by Doctor Garretson[1] of the University of Arizona. In Table VIII, the fourth-column figures are taken from his study of the distribution of marks given in Arizona public high schools for the second semester of the school year 1944-1945. Only those averages taken from schools with an enrollment over 1,000 are used here.

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1. O.K. Garretson, Marks in Arizona High Schools

Table VIII

Comparison of Means for Tucson Senior High School with those for Arizona High Schools of 1000 or More Students

Subjects	Means or Averages		
	Shop Group	Sample Group	Arizona High Schools over 1000 enrollment
English	3.30	2.83	3.04
Science	3.24	2.72	2.85
Commercial Courses	3.06	2.64	2.83
Social Science	3.26	2.63	2.92
Mathematics	3.02	2.84	3.04
Foreign Languages	3.27	2.93	2.78

It is interesting to note that for the first four subjects in Table VIII, the mean mark for all Arizona high schools enrolling over 1000 students falls between the means for our two groups from Tucson Senior High School. Perhaps this can be explained by assuming that the marks of shop students may be lower in all these schools and are included in the means given in column four. This causes the means to be lower than those of our sample group, thus producing a number very nearly equal to what we find when we average our two means for a subject. (Before averaging these means, it was necessary to multiply each by the number of students taking the subject in order to correct for the inequality in the number of cases.) Taking English again as an example, when we

average our two means of 3.30 and 2.83 the result is 3.07, only .03 from the mean shown in column four. The average of our two means for social science falls exactly on that shown for all large schools in Arizona, and for science and commercial courses the averages of our two means lie only .07 and .06 respectively from the ones shown in column four. Mathematics and foreign languages have shown some irregularity all the way through this study, and again in Table VIII do not follow the same pattern as the others.

It must be remembered while considering the above comparisons that Doctor Garretson obtained his averages from groups varying in size from 2400 to over 5000, while this study involved only 480 cases at the most.

SUMMARY

It has been shown that the 480 students, who were taking shop work at Tucson Senior High School during the first semester of the school year 1948-1949, ranked lower in academic work and in I.Q. scores than a group of similar size chosen at random from the 1990 who were not enrolled in shop courses. But, in variability the shop students were almost the same as those not taking shop work.

The average of 2.55 in shop courses, found in the early phases of this study, is the highest mean mark for any subject. Since the shop students exhibit a somewhat lower I.Q. and academic ability than those who were not in shop courses, one is inclined to speculate on the causes behind

this high average. It may be that shop teachers are unconsciously more lenient in marking than are the other teachers since the evaluation of shop projects is highly subjective. Or, the work may be definitely easier than academic work for most students. A third possibility is that the students who take shop courses are more interested in this work than are the students in academic classes. If none of these reasons were true, then we would have to assume that the shop students at Tucson High School were a selected group.

As to the central problem of this study -- the relation between success in academic subjects and success in shop work -- positive but slight correlation was found between the two types of work. Approximately the same degree of correlation was found between the shop success and the I.Q. scores as existed between the average of all the academic subjects and the shop work.

Because of the low correlation, any attempt to predict the mark that would be earned in shop work from the academic marks or the I.Q. score of any particular student, proved to be of comparatively little value.

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