[1]Calculating, Interpreting, and Reporting Estimates of "Effect Size" (Magnitude of an Effect or the Strength of a Relationship)

I. "Authors should report effect sizes in the manuscript and tables when reporting statistical significance" (Manuscript submission guidelines, *Journal of Agricultural Education*).

II. "For the reader to fully understand the importance of your findings, it is almost always necessary to include some index of effect size or strength of relationship in your Results section . . . . The general principle to be followed, however, is to provide the reader not only with information about statistical significance but also with enough information to assess the magnitude of the observed effect or relationship" (APA, 2001, pp. 25-26).

III. "Statistical significance is concerned with whether a research result is due to chance or sampling variability; practical significance is concerned with whether the result is useful in the real world" (Kirk, 1996, p. 746).

IV. Effect Size (Degree of Precision) as a Confidence Interval Around a Point Estimate of a Population Parameter.

A. Estimating the population mean (μ): Metric (interval or ratio) variables

1. Basic concepts

When a random sample is drawn from a population --

$\overline{X}$ is an unbiased estimate of μ ($\overline{X}$ = sample statistic; μ = population parameter)

Sampling error: Amount of error due to chance when estimating a population parameter from a sample statistic.

Sampling error = Statistic - Parameter
Sampling error = $\overline{X}$ - μ

When a random sample is drawn, sampling error can be estimated by calculating a confidence interval.

Excerpted from workshop notes of J. Robert Warmbrod, Distinguished University Professor Emeritus. (2001). "Conducting, Interpreting, and Reporting Quantitative Research," Research Pre-Session, National Agricultural Education Research Conference, December 11, New Orleans, LA.

2. Calculation of confidence interval (Hopkins, Hopkins, & Glass, 1996, pp. 155-158).

$$CI = \left[\overline{X} \pm t s_{\overline{x}}\right] \qquad s_{\overline{x}} = \frac{s_x}{\sqrt{n}}$$ (Standard error of the mean)

3. Example B: 95% Confidence Interval around an unbiased estimate of μ

<u>Research question</u>: For the population of graduate students completing the Research Methods course, estimate the mean score on the Final Exam. (n = 50)

SCORE Final Exam: Research Methods

		Frequency	Percent	Cumulative Percent
Valid	97	2	4.0	100.0
	95	6	12.0	96.0
	93	1	2.0	84.0
	92	3	6.0	82.0
	90	4	8.0	76.0
	88	5	10.0	68.0
	87	4	8.0	58.0
	85	4	8.0	50.0
	83	2	4.0	42.0
	82	2	4.0	38.0
	80	2	4.0	34.0
	78	4	8.0	30.0
	77	4	8.0	22.0
	75	1	2.0	14.0
	72	2	4.0	12.0
	70	2	4.0	8.0
	65	1	2.0	4.0
	37	1	2.0	2.0
	Total	50	100.0	

Statistics

SCORE Final Exam: Research Methods

N	Valid	50
	Missing	0
Mean		83.84
Std. Error of Mean		1.47
Median		86.00
Mode		95
Std. Deviation		10.41
Skewness		-1.963
Std. Error of Skewness		.337

$$CI = \left[\overline{X} \pm ts_{\overline{x}}\right]$$

df = 50 - 1 = 49; Critical value of $_{.975}t_{49} = 2.009$

$$83.84 \pm (2.009)\ (1.47)$$
$$83.84 \pm 2.95$$

Lower limit = 83.84 - 2.95 = 80.89
Upper limit = 83.84 + 2.95 = 86.79

$$C\ (80.9 \leq \mu \leq 86.8) = .95$$

Interpretation – Inference to the population. It is estimated with 95% confidence that the mean score on the Final Exam: Research Methods for the population of graduate students is within the interval 80.9 to 86.8.

4. Interpretation of confidence intervals

Construct a confidence interval around a sample statistic and on a population parameter.

Interpretation: ___ % (level of confidence) confident that the population parameter being estimated falls within the interval specified by the lower and upper limits of the confidence interval. Level of confidence = (1 - α).

If the researcher were to draw random samples and construct confidence intervals indefinitely, then (1 - α)% of the intervals produced would be expected to contain (capture) the population parameter.

B. Relationship between interval estimation and hypothesis testing (Example B)

Research question: For the population of graduate students completing the Research Methods course, is the mean score on the Final Exam equal to 85?

Statistical Hypothesis: H_0: $\mu = 85$ [Nondirectional (two-tailed) test]
Alternative Hypothesis: H_1: $\mu \neq 85$
Level of alpha: $\alpha = .05$

Sample data: $n = 50$
$\overline{X} = 83.84$
$s_x = 10.41$ (standard deviation of X)
$s_{\overline{x}} = 1.47$ (standard error of the mean)

Calculate test statistic: Test statistic is **t**; probability distribution is **t** distribution with **n - 1** degrees of freedom (t_{49})

Calculated t: $$t = \frac{\overline{X} - \mu}{s_{\overline{x}}} = \frac{83.84 - 85}{1.47} = -.788 \quad (p = .435)$$

Critical t: ${}_{.975}t_{49} = 2.009$

Decision: Calculated $|t| <$ critical $|t|$, fail to reject H_0
Probability associated with calculated t (.435) greater than α (.05), fail to reject H_0

For a given level of alpha:

- When the confidence interval includes the value hypothesized for the population parameter, **fail to reject H_0**

- When the confidence interval does not include the value hypothesized for the population parameter, **reject H_0**

C. Estimating the proportion of cases in the population (π) in a category of interest: categorical (nominal or ordinal) variable

1. Basic concepts

When a random sample is drawn from a population --

p-statistic is an unbiased estimate of π

p = sample statistic: proportion of cases in the sample in the category of interest

$p = \frac{f}{n}$ (f = number cases in sample in category; n = size of sample)

π = population parameter: proportion of cases in the population in the category of interest

Sampling error = p - π

When a random sample is drawn, sampling error can be estimated by calculating a confidence interval

2. Calculation of confidence interval (Hopkins, Hopkins, & Glass, 1996, pp.221-233)

$$CI = p \pm z\sqrt{\frac{p(1-p)}{n}} \; ; \quad \sqrt{\frac{p(1-p)}{n}} = \text{standard error of the proportion}$$

If the sampling fraction $\left(\frac{n}{N}\right) > .05$; $CI = p \pm z\sqrt{\frac{p(1-p)}{n}}\sqrt{1-\frac{n}{N}}$

3. Example C: 95% Confidence Interval around an unbiased estimate of π

Research question: For the population of graduate students completing the Research Methods course, estimate the proportion who were Ph. D. candidates.

DEGREE SOUGHT

		Frequency	Percent
Valid	1 MASTERS	152	50.7
	2 PH D	148	49.3
	Total	300	100.0

$$CI = p \pm z\sqrt{\frac{p(1-p)}{n}}\ \sqrt{1-\frac{n}{N}}$$

$$\text{Sampling fraction} = \frac{n}{N} = \frac{300}{982} = .31; \quad z_{.975} = 1.96$$

$$p \pm 1.96\sqrt{\frac{(.493)(.507)}{300}}\ \sqrt{1-\frac{300}{982}}$$

$p \pm (1.96)\ (.029)\ (.834)$
$p \pm .047$

Lower limit: .493 - .047 = .446
Upper limit: .493 + .047 = .540

$C\ (.446 \leq \pi \leq .540) = .95$

Interpretation – Inference to the population. It is estimated with 95% confidence that the proportion of graduate students enrolling in the Research Methods course who were Ph. D. candidates is within the interval .446 and .540.

D. Estimating the population correlation coefficient (ρ): Metric (interval or ratio) variable

1. Basic concepts

The absolute value of the Pearson product-moment coefficient (r) describes the magnitude (strength) of the relationship between variables; the sign of the coefficient (- or +) indicates the direction of the relationship.

Factors influencing the value of r:

Measurement error in X or Y can reduce the value of r: The greater the measurement error, the lower will be the observed r.

Variance of a variable influences r: The greater the variability among the observations, the greater the value of r.

Shape of distributions (frequency polygons of X and Y) influence r: (a) r can equal 1.0 only when the frequency distributions have the same shape and (b) the less similar the shapes of the distributions, the lower the maximum value of r.

ρ (rho) designates the correlation coefficient for the population

If $n \geq 25$, r is essentially an unbiased estimate of ρ

Statistical (null hypothesis): $H_0: \rho = 0$
$H_1: \rho \neq 0$ (nondirectional, two-tailed test)
$H_1: \rho > 0$ (directional, one-tailed test)
$H_1: \rho < 0$ (directional, one-tailed test)

Test statistic: Table values of r for various size of sample and level of alpha.

2. Calculation of confidence interval (Hopkins, Hopkins, & Glass, 1996, pp. 260-263).

Use Fisher's Z-transformation (Z_r) of r to calculate a confidence interval on the population correlation coefficient.

Z_r = Fisher's transformation of r

Confidence interval: $Z_r \pm z\,\sigma_{Z_r}$ Standard error of Z_r: $\sigma_{Z_r} = \frac{1}{\sqrt{n - 3}}$

3. Example D: 95% confidence interval around estimate of ρ

Research question: For the population of Extension employees, what is the magnitude and direction of the relationship between the extent "Organizational Issues" and "Financial Issues" limit their balancing of work/family roles?

Data:
$n = 181$
$r = .46$
$Z_r = .497$ (Fisher's Z transformation of r)

$\sigma_{Z_r} = \frac{1}{\sqrt{181 - 3}} = .075$ 95% confidence interval: $z = 1.96$

$.497 \pm (1.96)\,(.075)$
$.497 \pm .147$
Lower limit: $.497 - .147 = .350$ $r = .34$
Upper limit: $.497 + .147 = .644$ $r = .57$

$C\,(.34 \leq \rho \leq .57) = .95$

Interpretation – Inference to the Population. There is a moderate positive relationship between the extent "Organizational Issues" and "Financial Issues" limit Extension employees' balancing work/family roles. With 95% confidence , it is estimated that the magnitude of the relationship is within the range of .34 to .57.

E. Conventions for describing the magnitude of relationship.

Bartz (1994, p.184)

Value or r	Description
.80 or higher	Very High
.60 to .80	Strong
.40 to .60	Moderate
.20 to .40	Low
.20 or lower	Very Low

Hopkins (1997)

Value or r	Description
0.9 - 1.0	Nearly perfect, distinct
0.7 - 0.9	Very large, very high
0.5 - 0.7	High, large, major
0.3 - 0.5	Moderate, medium
0.1 - 0.3	Low, small, minor
0.0 - 0.1	Trivial, very small, insubstantial

Cohen (1988, pp. 75-107)

Small effect size: $r = .10$; $r^2 = .01$
Relationships of this size would not be perceptible on the basis of casual observation; many relationships pursued in "soft" behavioral science are of this order of magnitude.

Medium effect size: $r = .30$; $r^2 = .09$
This degree of relationship would be perceptible to the naked eye of a reasonably sensitive observer.

Large effect size: $r = .50$; $r^2 = .25$
This magnitude of relationship falls around the upper end of the range of correlation coefficients encountered in behavioral science; correlations "about as high as they come."

V. Estimating the Magnitude of Association in Contingency Tables: Categorical (nominal) variable.

(Glass & Hopkins, 1996, pp. 130-133; 333-336)
(Hays, 1994, pp. 866-869)

A. 2 x 2 contingency table: Phi coefficient (φ)

A phi coefficient of zero indicates independence (no association) between variables.

A phi coefficient of 1.0 indicates complete dependence (association) between the variables.

The phi coefficient is a Pearson product-moment coefficient calculated on two nominal-dichotomous variables when the categories of both variables are coded 0 and 1.

The phi coefficient can attain the value of 1.0 only if the distributions of the row and column variables are the same.

B. R x C contingency table: Cramer's V – Cramer's statistic

Used to describe the magnitude or association between categorical variables (nominal) when the number of rows, the number of columns, or both is greater than two.

Cramer's V must lie between 0 (reflecting complete independence) and 1.0 (indicating complete dependence or association) between the variables.

If the number of rows or the number of columns in the contingency table is two, the value of Cramer's V is identical to the value of phi.

C. Statistical (null) hypothesis (Chi-square test of independence)

H_0: Variables A and B are independent.
H_1: There is association between Variable A and Variable B.

Test statistic: χ^2 ; df = (R - 1) (C - 1)

D. Conventions for describing the magnitude of association in contingency tables (Rea & Parker, p. 203)

Value of φ or Cramer's V	Description
.00 and under .10	Negligible association
.10 and under .20	Weak association
.20 and under .40	Moderate association
.40 and under .60	Relatively strong association
.60 and under .80	Strong association
.80 to 1.00	Very strong association

VI. Estimating Effect Size for the Difference Between Two Means: Independent Groups

A. Calculating a confidence interval around the difference between sample means (Hopkins, Hopkins, & Glass, 1996, pp. 189-207; 209-213) (Cumming & Finch, 2001)

$$\text{Confidence Interval } (\mu_1 - \mu_2)\text{: } [(\overline{X}_1 - \overline{X}_2) \pm t\, s_{(\overline{X}_1 - \overline{X}_2)}]$$

Calculating the standard error of the difference between means: $s_{(\overline{X}_1 - \overline{X}_2)}$

Pooled variance: $$s_w^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 - 1) + (n_2 - 1)}$$

Pooled standard deviation of difference between means: $$s_w = \sqrt{s_w^2}$$

Standard error of difference between means: $$s_{(\overline{X}_1 - \overline{X}_2)} = s_w \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

Statistical (null) hypothesis:

H_0: $\mu_1 - \mu_2 = 0$
H_1: $\mu_1 - \mu_2 \neq 0$ (nondirectional; two-tailed test)
H_1: $\mu_1 - \mu_2 > 0$ (directional; one-tailed test)
H_1: $\mu_1 - \mu_2 < 0$ (directional; one-tailed test)

Test statistic: t; $df = n_1 + n_2 - 2$

$$t = \frac{\overline{X}_1 - \overline{X}_2}{s_{\overline{x}_1 - \overline{x}_2}} \qquad \frac{\text{(difference between sample means)}}{\text{(standard error difference between means}}$$

B. Cohen's "effect size" index: d (Cohen, 1988, pp. 19-74)

1. d = a standardized effect size index.
2. The raw difference (in the original measurement unit) between the sample means on the dependent variable is divided by the estimated pooled standard deviation of the dependent variable in the populations from which random samples are drawn.
3. Cohen's d statistic expresses the difference between means (effect size) in standard deviation units.
4. Effect size descriptors:

   Small effect size: d = .20

   Medium effect size: d = .50

   Large effect size: d = .80

5. Calculation of d

$$d = \frac{\overline{X}_1 - \overline{X}_2}{s_w} \qquad \frac{\text{(difference between sample means)}}{\text{(pooled standard deviation)}}$$

6. Calculation of d from significant t-test of H_0: $\mu_1 - \mu_2 = 0$ (Rosenthal, 1994)

$$d = \frac{t\,(n_1 + n_2)}{\sqrt{df}\,\sqrt{n_1}\,\sqrt{n_2}}$$

When $n_1 = n_2$: $d = \frac{2t}{\sqrt{df}}$

t = calculated t; $df = n_1 + n_2 - 2$

C. Example E: Effect size for difference between means

Research question: For the populations of graduate students completing the Research Methods course, do M. S. candidates differ from Ph. D. candidates in the mean number of courses in statistics and research completed prior to enrollment in Research Methods?

Group Statistics

	DEGREE SOUGHT	N	Mean	Std. Deviation
NUMBER COURSES IN STATISTICS-RESEARC	1 M. S.	75	1.16	1.04
	2 Ph. D.	75	2.11	1.38

Independent Samples Test

NUMBER COURSES IN STATISTICS-RESEARCH

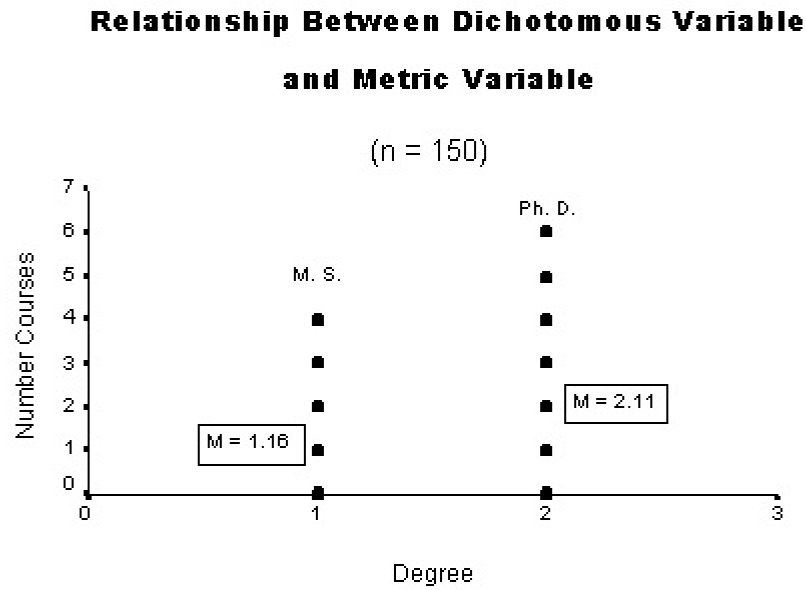
			Equal variances assumed
Levene's Test for Equality of Variances	F		2.316
	Sig.		.130
t-test for Equality of Means	t		-4.742
	df		148
	Sig. (2-tailed)		.000
	Mean Difference		-.95
	Std. Error Difference		.20
	95% Confidence Interval of the Difference	Lower	-1.34
		Upper	-.55

H_0: $\mu_1 - \mu_2 = 0$
H_1: $\mu_1 - \mu_2 \neq 0$
$\alpha = .05$

Calculated $t = -4.74$; $p < .001$

95% confidence interval: $C(-1.34 \leq \mu_1 - \mu_2 \leq -.55) = .95$

Effect size: $d = \dfrac{(1.16 - 2.11)}{1.22} = -.78$



Point-biserial r = .36

Calculation of r_{pb} from d (Rosenthal, 1994)

$$r_{pb} = \sqrt{\frac{d^2}{d^2 + 4}} = \sqrt{\frac{(.78)^2}{(.78)^2 + 4}} = .36$$

Calculation of r_{pb} from t (Rosenthal, 1994)

$$r_{pb} = \sqrt{\frac{t^2}{t^2 + df}} = \sqrt{\frac{(4.742)^2}{(4.742)^2 + 148}} = .36$$

VII. Estimating Effect Size for the Difference between two means: Dependent Groups (Paired Observations).

A. Calculating a confidence interval around the difference between sample means (Hopkins, Hopkins, & Glass, 1996, pp. 208-209)

Confidence interval for $(\mu_1 - \mu_2)$: $[(\overline{X}_1 - \overline{X}_2) \pm t\, s_{\overline{D}}]$

Difference score for each case: $X_D = (X_1 - X_2)$

Variance of difference scores: s_D^2

Standard deviation of difference scores: $s_D = \sqrt{s_D^2}$

Standard error of difference between means: $s_{\overline{D}} = \frac{s_D}{\sqrt{n}}$

Statistical (null) hypothesis:

H_0: $\mu_1 - \mu_2 = 0$
H_1: $\mu_1 - \mu_2 \neq 0$ (nondirectional; two-tailed test)
H_1: $\mu_1 - \mu_2 > 0$ (directional; one-tailed test)
H_1: $\mu_1 - \mu_2 < 0$ (directional; one-tailed test)

Test statistic: t; df = n - 1

$$t = \frac{\overline{X}_1 - \overline{X}_2}{s_{\overline{D}}}$$

Cohen's "effect size" index: d (Cohen, 1988, pp. 19-74)

Small effect size: d = .20
Medium effect size: d = .50
Large effect size: d = .80

Calculation of d:

$$d = \frac{\overline{X}_1 - \overline{X}_2}{s_D} \qquad \frac{\text{(difference between sample means)}}{\text{(standard deviation of difference scores)}}$$

Calculation of d from significant t-test of H_0: $\mu_1 - \mu_2 = 0$

$$d = \frac{t}{\sqrt{n}}$$

B. Example F:

Research question: For the population of Extension employees, is there a difference between the extent "Organizational Issues" and "Financial Issues" limit their balancing of work/life roles?

Paired Samples Statistics

		Mean	N	Std. Deviation
Pair 1	Organizational Issues	2.8149	181	1.0154
	Financial Issues	2.5801	181	1.1549

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 Organizational Issues - Financial Issues	.2348	1.1345	.084	.0684	.4012	2.784	180	.006

Effect size: $d = \frac{\overline{X}_1 - \overline{X}_2}{s_D} = \frac{2.81 - 2.58}{1.13} = .20$

VIII. Estimating Effect Size for Differences Between k Means (Independent Groups) One-Way Analysis of Variance

A. Statistical (null) hypothesis:

H_0: $\mu_1 = \mu_2 = \ldots = \mu_k$
H_1: $\mu_1 \neq \mu_2 \neq \ldots = \mu_k$

Test statistic: F; k = number of independent groups

B. Indices of effect size

1. Eta squared (η^2): proportion of variance in the dependent variable explained by the group (categorical) variable.

   eta (η) $= \sqrt{\eta^2}$: correlation ratio – magnitude of the relationship between the dependent variable and the group (categorical) variable.

   Calculation of eta squared: $\eta^2 = \dfrac{SS_{Bet}}{SS_{Total}}$

2. R^2 : proportion of variance in the dependent variable explained by a linear combination of dichotomous dummy independent variables that represent the group (categorical) variable.

   $R^2 = \eta^2$

3. Omega squared (ω^2) : estimate of the proportion of variance in the dependent variable accounted for by the categorical independent variable (Hays, 1994, pp. 408-410)

   η^2 and R^2 tend "to be somewhat optimistic as an assessment of the true relationship between group membership and the dependent variable" (Hays, 1994, p. 408)

   <u>Effect size index (Kirk, 1996, p.751)</u>
   Small effect size: $\omega^2 = .010$
   Medium effect size: $\omega^2 = .059$
   Large effect size: $\omega^2 = .138$

   $$\omega^2 = \frac{SS_{between} - (k - 1)\,MS_{within}}{SS_{total} + MS_{within}}$$ Where k = number of groups

4. Cohen's effect size index: f (Cohen, 1988, pp. 280-288)

   $$f = \sqrt{\frac{\eta^2}{1 - \eta^2}}$$

Small effect size: f = .10 – standard deviation of the k group means that is one-tenth as large as the standard deviation of the observations within all groups; equivalent to d = .20 when there are two independent groups.

Medium effect size: f = .25 – standard deviation of the k group means that is one-quarter as large as the standard deviation of the observations within all groups; equivalent to d = .50 when there are two independent groups.

Large effect size: f = .40 – standard deviation of the k group means that is .40 of the standard deviation of the observations within all groups; equivalent to d = .80 when there are two independent groups.

C. Example G: (One-way analysis of variance)

Statistical (null) hypothesis:

H_0: $\mu_{\text{(methods only)}} = \mu_{\text{(design only)}} = \mu_{\text{(both courses)}}$
H_1: $\mu_{\text{(methods only)}} \neq \mu_{\text{(design only)}} \neq \mu_{\text{(both courses)}}$
$\alpha = .05$

Descriptives

COURSES NUMBER COURSES IN STATISTICS-RESEARCH

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1 Methods Only	50	1.12	1.26	.18	.76	1.48
2 Design Only	50	2.20	1.16	.16	1.87	2.53
3 Both Courses	50	1.58	1.30	.18	1.21	1.95
Total	150	1.63	1.31	.11	1.42	1.84

ANOVA

COURSES NUMBER COURSES IN STATISTICS-RESEARCH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	29.373	2	14.687	9.576	.000
Within Groups	225.460	147	1.534		
Total	254.833	149			

Multiple Comparisons

Dependent Variable: COURSES NUMBER COURSES IN STATISTICS-RESEARCH
LSD

(I) ENROLL COURSES ENROLL I	(J) ENROLL COURSES ENROLL I	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1 Methods Only	2 Design Only	-1.08*	.25	.000	-1.57	-.59
	3 Both Courses	-.46	.25	.065	-.95	.03
2 Design Only	1 Methods Only	1.08*	.25	.000	.59	1.57
	3 Both Courses	.62*	.25	.013	.13	1.11
3 Both Courses	1 Methods Only	.46	.25	.065	-.03	.95
	2 Design Only	-.62*	.25	.013	-1.11	-.13

*. The mean difference is significant at the .05 level.

Effect size: $\eta^2 = \dfrac{29.37}{254.83} = .115$

$$\omega^2 = \frac{29.37 - (2)(1.53)}{254.83 + 1.53} = .10$$

$$f = \sqrt{\frac{.115}{1 - .115}} = .36$$

IX. Multiple Linear Regression

A. Statistical (null) hypothesis:

H_0: $R^2 = 0$
H_1: $R^2 \neq 0$

Test statistic: $_{(1 - \alpha)} F_{(k, n-k-1)}$ k = number independent variables

B. Cohen's effect size index: f^2 (Cohen, 1988, pp. 410-414)

$$f^2 = \frac{R^2_{Y.X_1...X_k}}{1 - R^2_{Y.X_1...X_k}} \qquad \frac{\text{(proportion of variance explained)}}{\text{(proportion of variance not explained)}}$$

Effect Size	f^2	R^2	R	Comparable r for simple linear regression
Small	.02	.0196	.14	.10
Medium	.15	.1300	.36	.30
Large	.35	.2600	.51	.50

C. Example H: Multiple linear regression

Source of data: Wolf, K. N. (1994). *The relationship among task expertise, general problem solving confidence, and self-efficacy to solve work-related problems in a group setting*. Ph. D. Dissertation, The Ohio State University.

Research question: Controlling for level of education completed by hospital dietetic services personnel, to what extent can variability in the workers' perceptions of self-efficacy in group problem solving be explained by their experience in problem solving groups, expertise in their work area, problem-solving confidence, and orientation toward group problem solving?

Table 7
Summary Data: Regression of Self-Efficacy in Group Problem Solving on Selected Independent Variables (n = 158)

	Intercorrelations									
Variables	**X_1**	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**Y**	**Mean**	**SD**
Level of Education[a]										
EDUC_AD (X_1)	1.00	-.16	-.10	-.05	-.03	-.01	.23	-.03	.08	.28
EDUC_BS (X_2)		1.00	-.18	-.08	.10	.07	.24	.35	.23	.42
EDUC_MS (X_3)			1.00	.07	.08	.03	.22	.29	.10	.30
CONFDENT (X_4)				1.00	-.16	.37	-.09	-.18	27.41	5.25
EXPERT1 (X_5)					1.00	.09	.28	.53	27.51	8.55
ORIENT (X_6)						1.00	-.02	.02	29.56	4.62
GROUPSPS (X_7)[b]							1.00	.41	.62	.49
EFFICACY (Y)								1.00	37.63	13.01

[a] EDUC_AD: 0 = Not associate degree; 1= Associate degree; EDUC_BS: 0 = Not bachelor's degree; 1 = Bachelor's degree; EDUC_MS: 0 = Not master's degree; 1 = Master's degree; Comparison Group: High School.
[b] 0 = No experience in problem solving; 1 = Experience in problem solving.

Table 8
Regression of Self-Efficacy in Group Problem Solving on Level of Education, Confidence in Problem Solving, Orientation Toward Problem Solving, Expertise in Work Area, and Experience in Group Problem-Solving (n = 158)

	Step 1			Full Model		
Variables	**b**	**t**	**p**	**b**	**t**	**p**
Level of Education [a]						
EDUC_AD	3.55	1.06	.29	1.35	.45	.65
EDUC_BS	13.18	5.93	<.01	10.11	5.03	<.01
EDUC_MS	16.32	5.32	<.01	13.01	4.77	<.01
(Constant)	32.68					
CONFDENT				-.24	-1.51	.13
EXPERT1				.64	6.75	<.01
GROUPSPS [b]				3.46	1.88	.06
ORIENT				-.02	-.13	.89
(Constant)				21.48		

[a] EDUC_AD: 0 = Not associate degree; 1= Associate degree; EDUC_BS: 0 = Not bachelor's degree; 1 = Bachelor's degree; EDUC_MS: 0 = Not master's degree; 1 = Master's degree; Comparison Group: High School.
[b] 0 = No experience in problem solving; 1 = Experience in problem solving.

Step 1: $R^2 = .26$; $F = 17.70$; $p < .001$
Step 2: R^2 change$_{(\text{CONFDENT, EXPERT1, GROUPSPS, ORIENT})}$ = .23; $F = 17.39$; $p < .001$

Full Model: $R^2 = .49$; Adjusted $R^2 = .47$; $F = 20.76$; $p < .001$

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