RATIOMERA

Exercise Sheet

Multiple Regression

Ratiomera Statistics

This sheet contains 90 exercises organized into 9 learning-objective groups. Work through each exercise before consulting its matching complete solution. Show the relevant formula or rule, substituted values, units, and an interpretation. All settings, values, data, and software outputs are constructed teaching material; they are not empirical findings.

Part I: Theory

A06: Constructing Dummy Indicators and Finding the Reference

`T07-A06-V01`: Tutorial format

In a constructed model, the categorical predictor tutorial format has $k = 3$ categories: Text, Video, Interactive. Use Text as the reference category and keep an intercept. Let D_1 through D_2 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 61.00 + 3.50D_1 + 6.00D_2$ for reasoning score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V02`: Study location

In a constructed model, the categorical predictor study location has $k = 4$ categories: Home, Library, Study room, Outdoors. Use Home as the reference category and keep an intercept. Let D_1 through D_3 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 54.00 + 4.00D_1 + 2.50D_2 - 1.50D_3$ for focus score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V03`: Feedback channel

In a constructed model, the categorical predictor feedback channel has $k = 3$ categories: Written, Audio, Video. Use Written as the reference category and keep an intercept. Let D_1 through D_2 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 66.00 + 2.00D_1 + 4.50D_2$ for revision score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V04`: Note-taking method

In a constructed model, the categorical predictor note-taking method has $k = 4$ categories: Paper, Tablet, Laptop, Mixed. Use Paper as the reference category and keep an intercept. Let D_1 through D_3 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 58.00 - 1.50D_1 - 2.50D_2 + 3.00D_3$ for recall score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V05`: Workshop schedule

In a constructed model, the categorical predictor workshop schedule has $k = 3$ categories: Morning, Afternoon, Evening. Use Morning as the reference category and keep an intercept. Let D_1 through D_2 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 49.00 + 2.50D_1 - 3.00D_2$ for confidence score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V06`: Archive guide

In a constructed model, the categorical predictor archive guide has $k = 4$ categories: Checklist, Map, Mentor, Search tool. Use Checklist as the reference category and keep an intercept. Let D_1 through D_3 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 63.00 + 1.50D_1 + 5.00D_2 + 3.00D_3$ for retrieval score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V07`: Revision strategy

In a constructed model, the categorical predictor revision strategy has $k = 3$ categories: Self-review, Peer review, Instructor review. Use Self-review as the reference category and keep an intercept. Let D_1 through D_2 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 60.00 + 4.00D_1 + 7.00D_2$ for quality score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V08`: Museum route

In a constructed model, the categorical predictor museum route has $k = 5$ categories: Chronological, Thematic, Free choice, Guided, Hybrid. Use Chronological as the reference category and keep an intercept. Let D_1 through D_4 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 57.00 + 3.00D_1 - 1.00D_2 + 5.50D_3 + 4.00D_4$ for knowledge score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on

D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V09`: Study plan

In a constructed model, the categorical predictor study plan has $k = 3$ categories: Daily, Twice weekly, Weekly. Use Daily as the reference category and keep an intercept. Let D_1 through D_2 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 69.00 - 2.00D_1 - 5.00D_2$ for retention score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

`T07-A06-V10`: Task interface

In a constructed model, the categorical predictor task interface has $k = 4$ categories: List, Board, Calendar, Timeline. Use List as the reference category and keep an intercept. Let D_1 through D_3 identify the nonreference categories in the order listed. The fitted model is $\hat{Y} = 62.00 + 2.50D_1 + 4.00D_2 + 1.00D_3$ for completion score.

(a) State how many indicators are required and why. (b) Construct the complete zero-one coding table for every category. (c) Identify the reference row, calculate each category's fitted value, and interpret the coefficient on D_1 as a comparison with the reference. (d) Explain why adding a separate indicator for all k categories while retaining the intercept creates exact redundancy, and describe what would change and stay unchanged if a different reference were chosen.

Part II: Calculator Practice

A01: Reading a Multiple-Regression Equation and Output

`T07-A01-V01`: Guided practice and reasoning

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 80 cases. Its outcome Y is reasoning score in points; X_1 is guided-practice hours, and X_2 is prior-preparation score. The fitted intercept is 38.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	2.400	0.580	0.419	0.550
X_2	0.310	0.108	0.292	0.480

The model reports $R^2 = 0.370$, adjusted $R^2 = 0.354$, residual standard error $= 5.60$ points, and residual $df = 77$.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase "with the other predictor held fixed." (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

`T07-A01-V02`: Archive workflow and retrieval time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 72 cases. Its outcome Y is retrieval time in minutes; X_1 is checklist-practice sessions, and X_2 is archive-experience months. The fitted intercept is 70.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	−1.750	0.467	−0.407	−0.510
X_2	−0.220	0.093	−0.257	−0.420

The model reports $R^2 = 0.316$, adjusted $R^2 = 0.296$, residual standard error $= 4.80$ minutes, and residual $df = 69$.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase “with the other predictor held fixed.” (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

`T07-A01-V03`: Reading routines and comprehension

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 95 cases. Its outcome Y is comprehension score in points; X_1 is weekly reading hours, and X_2 is baseline-vocabulary score. The fitted intercept is 42.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	1.850	0.443	0.383	0.490
X_2	0.280	0.084	0.306	0.440

The model reports $R^2 = 0.322$, adjusted $R^2 = 0.308$, residual standard error $= 5.10$ points, and residual $df = 92$.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase “with the other predictor held fixed.” (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

`T07-A01-V04`: Route rehearsal and navigation time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 68 cases. Its outcome Y is navigation time in minutes; X_1 is route-rehearsal attempts, and X_2 is route-familiarity score. The fitted intercept is 65.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	−2.100	0.519	−0.446	−0.530
X_2	−0.160	0.080	−0.220	−0.390

The model reports $R^2 = 0.322$, adjusted $R^2 = 0.302$, residual standard error $= 6.00$ minutes, and residual $df = 65$.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase “with the other predictor held fixed.” (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

T07-A01-V05: Search practice and catalog accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 110 cases. Its outcome Y is catalog-accuracy score in points; X_1 is search-practice sets, and X_2 is prior catalog-knowledge score. The fitted intercept is 48.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	1.550	0.413	0.339	0.460
X_2	0.340	0.107	0.288	0.430

The model reports $R^2 = 0.280$, adjusted $R^2 = 0.266$, residual standard error $= 4.60$ points, and residual $df = 107$.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase “with the other predictor held fixed.” (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

T07-A01-V06: Workshop participation and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 76 cases. Its outcome Y is confidence score in points; X_1 is workshop sessions, and X_2 is baseline-confidence score. The fitted intercept is 30.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	2.200	0.546	0.395	0.500
X_2	0.450	0.125	0.352	0.470

The model reports $R^2 = 0.363$, adjusted $R^2 = 0.345$, residual standard error $= 5.00$ points, and residual $df = 73$.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase “with the other predictor held fixed.” (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

T07-A01-V07: Focus blocks and task accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 120 cases. Its outcome Y is task-accuracy score in points; X_1 is notification-free blocks, and X_2 is sleep duration in hours. The fitted intercept is 55.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	1.300	0.330	0.329	0.410

Term	Estimate	SE	Standardized	Bivariate r
X_2	1.150	0.335	0.288	0.380

The model reports $R^2 = 0.244$, adjusted $R^2 = 0.231$, residual standard error $= 4.30$ points, and residual $df =$ 117.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase "with the other predictor held fixed." (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

`T07-A01-V08`: Museum engagement and historical knowledge

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 84 cases. Its outcome Y is historical-knowledge score in points; X_1 is museum visits, and X_2 is prior-history score. The fitted intercept is 40.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	2.650	0.619	0.411	0.520
X_2	0.370	0.118	0.302	0.450

The model reports $R^2 = 0.350$, adjusted $R^2 = 0.334$, residual standard error $= 5.50$ points, and residual $df =$ 81.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase "with the other predictor held fixed." (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

`T07-A01-V09`: Peer feedback and revision quality

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 92 cases. Its outcome Y is revision-quality score in points; X_1 is peer-feedback rounds, and X_2 is baseline-writing score. The fitted intercept is 44.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	2.100	0.507	0.391	0.480
X_2	0.300	0.104	0.271	0.400

The model reports $R^2 = 0.296$, adjusted $R^2 = 0.280$, residual standard error $= 4.90$ points, and residual $df =$ 89.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase "with the other predictor held fixed." (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

T07-A01-V10: Planning sessions and completion time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed study uses 88 cases. Its outcome Y is completion time in minutes; X_1 is planning sessions, and X_2 is task-complexity score. The fitted intercept is 82.000. The selected output is:

Term	Estimate	SE	Standardized	Bivariate r
X_1	−1.900	0.384	−0.430	−0.450
X_2	0.850	0.185	0.398	0.420

The model reports $R^2 = 0.361$, adjusted $R^2 = 0.346$, residual standard error $= 5.70$ minutes, and residual $df = 85$.

(a) Write the fitted equation and explain how an unstandardized estimate differs from a standardized coefficient. (b) Interpret both unstandardized slopes conditionally, using the outcome unit and the phrase "with the other predictor held fixed." (c) Calculate each t statistic as estimate divided by its standard error, obtain the two-sided p values, and decide at $\alpha = .05$. (d) Interpret R^2, adjusted R^2, and the residual standard error, then explain why each standardized multiple-regression coefficient can differ from its bivariate correlation.

A02: Comparing a Prespecified Nested Model Sequence

T07-A02-V01: Guided practice and reasoning

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 70$ cases, the same reasoning score outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 1840.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	guided-practice hours	1	0.220
M2	guided-practice hours; prior-preparation score	2	0.370
M3	guided-practice hours; prior-preparation score; reflection-session count	3	0.390

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding reflection-session count. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R^2_U - R^2_R)/1]/[(1 - R^2_U)/(n - 3 - 1)]$ with 1 and 66 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

T07-A02-V02: Archive workflow and retrieval time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 80$ cases, the same retrieval time outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 1320.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	checklist-practice sessions	1	0.280
M2	checklist-practice sessions; archive-experience months	2	0.350
M3	checklist-practice sessions; archive-experience months; catalog-familiarity score	3	0.351

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding catalog-familiarity score. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R_U^2 - R_R^2)/1]/[(1 - R_U^2)/(n - 3 - 1)]$ with 1 and 76 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

`T07-A02-V03`: Reading routines and comprehension

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 60$ cases, the same comprehension score outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 1560.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	weekly reading hours	1	0.180
M2	weekly reading hours; baseline-vocabulary score	2	0.310
M3	weekly reading hours; baseline-vocabulary score; annotation-session count	3	0.360

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding annotation-session count. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R_U^2 - R_R^2)/1]/[(1 - R_U^2)/(n - 3 - 1)]$ with 1 and 56 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

`T07-A02-V04`: Route rehearsal and navigation time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 90$ cases, the same navigation time outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 2100.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	route-rehearsal attempts	1	0.250
M2	route-rehearsal attempts; route-familiarity score	2	0.330
M3	route-rehearsal attempts; route-familiarity score; landmark-recall score	3	0.334

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding landmark-recall score. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R_U^2 - R_R^2)/1]/[(1 - R_U^2)/(n - 3 - 1)]$ with 1 and 86 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

`T07-A02-V05`: Search practice and catalog accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 100$ cases, the same catalog-accuracy score outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 1750.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	search-practice sets	1	0.300
M2	search-practice sets; prior catalog-knowledge score	2	0.410
M3	search-practice sets; prior catalog-knowledge score; query-planning score	3	0.440

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding query-planning score. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R_U^2 - R_R^2)/1]/[(1 - R_U^2)/(n - 3 - 1)]$ with 1 and 96 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

T07-A02-V06: Workshop participation and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 55$ cases, the same confidence score outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 980.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	workshop sessions	1	0.160
M2	workshop sessions; baseline-confidence score	2	0.290
M3	workshop sessions; baseline-confidence score; reflection-log count	3	0.292

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding reflection-log count. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R_U^2 - R_R^2)/1]/[(1 - R_U^2)/(n - 3 - 1)]$ with 1 and 51 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

T07-A02-V07: Focus blocks and task accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 120$ cases, the same task-accuracy score outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 2280.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	notification-free blocks	1	0.210
M2	notification-free blocks; sleep duration in hours	2	0.340
M3	notification-free blocks; sleep duration in hours; planning-break count	3	0.370

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding planning-break count. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R_U^2 - R_R^2)/1]/[(1 - R_U^2)/(n - 3 - 1)]$

with 1 and 116 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

`T07-A02-V08`: Museum engagement and historical knowledge

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 75$ cases, the same historical-knowledge score outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 1440.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	museum visits	1	0.240
M2	museum visits; prior-history score	2	0.320
M3	museum visits; prior-history score; exhibit-note count	3	0.321

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding exhibit-note count. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R_U^2 - R_R^2)/1]/[(1 - R_U^2)/(n - 3 - 1)]$ with 1 and 71 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

`T07-A02-V09`: Peer feedback and revision quality

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 65$ cases, the same revision-quality score outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 1620.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	peer-feedback rounds	1	0.190
M2	peer-feedback rounds; baseline-writing score	2	0.360
M3	peer-feedback rounds; baseline-writing score; revision-plan score	3	0.420

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding revision-plan score. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R_U^2 - R_R^2)/1]/[(1 - R_U^2)/(n - 3 - 1)]$ with 1 and 61 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

`T07-A02-V10`: Planning sessions and completion time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Three constructed ordinary least-squares models use the same $n = 110$ cases, the same completion time outcome, and an intercept. Each later model contains every term in the earlier model. The common total sum of squares is $SST = 1960.0$, and p denotes the number of predictor coefficients.

Model	Predictor set	p	R-squared
M1	planning sessions	1	0.270
M2	planning sessions; task-complexity score	2	0.390
M3	planning sessions; task-complexity score; progress-check count	3	0.395

(a) Calculate the residual sum of squares $SSE = SST(1 - R^2)$ for every model and the change in R^2 at each step after M1. (b) Calculate adjusted $R^2 = 1 - (1 - R^2)(n - 1)/(n - p - 1)$ for all three models. (c) Describe what ordinary and adjusted R^2 say about adding progress-check count. (d) Treat M2 as the restricted model and M3 as the unrestricted model. Write both model equations, state the null hypothesis for the added coefficient, and calculate the incremental test $F = [(R^2_U - R^2_R)/1]/[(1 - R^2_U)/(n - 3 - 1)]$ with 1 and 106 degrees of freedom. Obtain its p-value and interpret the decision. (e) Explain why this is a valid nested sequence and why neither the fit table nor the incremental test establishes causality or new-data performance.

A03: Distinguishing the Global F Test From Coefficient t Tests

`T07-A03-V01`: Guided practice and reasoning

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for reasoning score uses $n = 50$ and reports $R^2 = 0.220$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,46} = 2.80684$. Its coefficient table is:

Predictor	Estimate	SE
guided-practice hours	1.800	0.600
prior-preparation score	0.220	0.180
reflection sessions	0.120	0.160

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 46 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

`T07-A03-V02`: Archive workflow and retrieval time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for retrieval time uses $n = 60$ and reports $R^2 = 0.300$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,56} = 2.76943$. Its coefficient table is:

Predictor	Estimate	SE
checklist-practice sessions	−1.400	0.450
archive-experience months	−0.200	0.160
catalog familiarity	0.300	0.120

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 56 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

`T07-A03-V03`: Reading routines and comprehension

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for comprehension score uses $n = 70$ and reports $R^2 = 0.100$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,66} = 2.74371$. Its coefficient table is:

Predictor	Estimate	SE
weekly reading hours	1.100	0.580
baseline-vocabulary score	0.180	0.130
annotation sessions	−0.150	0.140

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 66 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

`T07-A03-V04`: Route rehearsal and navigation time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for navigation time uses $n = 80$ and reports $R^2 = 0.250$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,76} = 2.72494$. Its coefficient table is:

Predictor	Estimate	SE
route-rehearsal attempts	−1.800	0.550
route-familiarity score	−0.120	0.100
landmark recall	0.280	0.110

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 76 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero.

identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

T07-A03-V05: Search practice and catalog accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for catalog-accuracy score uses $n = 90$ and reports $R^2 = 0.080$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,86} = 2.71065$. Its coefficient table is:

Predictor	Estimate	SE
search-practice sets	1.000	0.570
prior catalog-knowledge score	0.150	0.120
query planning	0.180	0.140

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 86 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

T07-A03-V06: Workshop participation and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for confidence score uses $n = 100$ and reports $R^2 = 0.350$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,96} = 2.69939$. Its coefficient table is:

Predictor	Estimate	SE
workshop sessions	2.100	0.500
baseline-confidence score	0.380	0.140
reflection logs	−0.100	0.130

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 96 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

T07-A03-V07: Focus blocks and task accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for task-accuracy score uses $n = 110$ and reports $R^2 = 0.200$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,106} = 2.69030$. Its coefficient table is:

Predictor	Estimate	SE
notification-free blocks	1.300	0.400

Predictor	Estimate	SE
sleep duration in hours	0.120	0.110
planning breaks	0.250	0.150

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 106 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

`T07-A03-V08`: Museum engagement and historical knowledge

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for historical-knowledge score uses $n = 120$ and reports $R^2 = 0.280$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,116} = 2.68281$. Its coefficient table is:

Predictor	Estimate	SE
museum visits	2.000	0.480
prior-history score	0.310	0.130
exhibit notes	0.080	0.120

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 116 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

`T07-A03-V09`: Peer feedback and revision quality

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for revision-quality score uses $n = 75$ and reports $R^2 = 0.160$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,71} = 2.73365$. Its coefficient table is:

Predictor	Estimate	SE
peer-feedback rounds	1.200	0.520
baseline-writing score	0.190	0.150
revision planning	−0.090	0.130

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 71 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

`T07-A03-V10`: Planning sessions and completion time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed three-predictor model for completion time uses $n = 65$ and reports $R^2 = 0.240$. Let β_1, β_2, and β_3 denote the three population slopes. For $\alpha = .05$, the supplied critical value is $F_{3,61} = 2.75548$. Its coefficient table is:

Predictor	Estimate	SE
planning sessions	−1.600	0.500
task-complexity score	0.420	0.170
progress checks	0.160	0.140

(a) State the global null hypothesis, calculate $F = (R^2/3)/[(1 - R^2)/(n - 3 - 1)]$, and make the global decision. (b) For each predictor, calculate $t = b/SE$, its two-sided p value with 61 residual degrees of freedom, and the decision at $\alpha = .05$. (c) State the individual coefficient null and explain why a global result does not identify which slope differs from zero. (d) Reconcile this model's global and individual decisions without treating either kind of test as proof of importance, prediction, or causality.

A04: Semipartial Correlation and Incremental R-Squared

`T07-A04-V01`: Guided practice and reasoning

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for reasoning score already contains guided-practice hours and prior-preparation score, with $R^2 = 0.300$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
reflection sessions	0.240
study-partner meetings	0.100
planning checks	−0.180

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

`T07-A04-V02`: Archive workflow and retrieval time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for retrieval time already contains checklist-practice sessions and archive-experience months, with $R^2 = 0.260$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
catalog familiarity	−0.120
desk-map use	−0.270
mentor consultations	0.080

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

`T07-A04-V03`: Reading routines and comprehension

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for comprehension score already contains weekly reading hours and baseline-vocabulary score, with $R^2 = 0.340$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
annotation sessions	0.150
discussion posts	0.310
quiet-reading blocks	0.200

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

`T07-A04-V04`: Route rehearsal and navigation time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for navigation time already contains route-rehearsal attempts and route-familiarity score, with $R^2 = 0.290$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
landmark recall	−0.280
map checks	−0.140
route previews	0.190

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

T07-A04-V05: Search practice and catalog accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for catalog-accuracy score already contains search-practice sets and prior catalog-knowledge score, with $R^2 = 0.370$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
query planning	0.110
keyword rehearsals	0.220
catalog hints used	0.290

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

T07-A04-V06: Workshop participation and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for confidence score already contains workshop sessions and baseline-confidence score, with $R^2 = 0.320$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
reflection logs	0.260
peer meetings	0.170
practice demonstrations	−0.090

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

T07-A04-V07: Focus blocks and task accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for task-accuracy score already contains notification-free blocks and sleep duration in hours, with $R^2 = 0.250$. Each candidate below was separately regressed on those current predictors.

The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
planning breaks	0.130
screen-free intervals	0.210
task previews	0.070

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

`T07-A04-V08`: Museum engagement and historical knowledge

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for historical-knowledge score already contains museum visits and prior-history score, with $R^2 = 0.310$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
exhibit notes	0.180
guided-tour stops	0.120
follow-up readings	0.250

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

`T07-A04-V09`: Peer feedback and revision quality

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for revision-quality score already contains peer-feedback rounds and baseline-writing score, with $R^2 = 0.360$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
revision planning	0.090
peer comments used	0.280

Candidate	Semipartial r
editing passes	0.160

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

`T07-A04-V10`: Planning sessions and completion time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed current model for completion time already contains planning sessions and task-complexity score, with $R^2 = 0.280$. Each candidate below was separately regressed on those current predictors. The residual from that regression is the candidate's part not linearly predicted by the current set. The table reports the correlation between that residualized candidate and the original, not residualized, outcome. The symbol r_{sp} denotes this semipartial correlation:

Candidate	Semipartial r
progress checks	−0.230
calendar reminders	−0.110
task previews	0.200

(a) Explain why this is a semipartial correlation rather than a partial correlation. (b) For each one-candidate addition, calculate $\Delta R^2 = r_{sp}^2$ and the resulting R^2. (c) If a forward step uses the largest increment, identify the chosen candidate and quantify its increment. (d) Explain what this step does and does not justify, including why it neither proves that the chosen variable is true or causal nor guarantees that it will remain best after another term enters.

A05: Comparing Prespecified Candidate Models With AIC

`T07-A05-V01`: Guided practice and reasoning

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same reasoning score outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	guided-practice hours	3	−155.0
M2	guided-practice hours + prior-preparation score	4	−146.0
M3	guided-practice hours + prior-preparation score + reflection-session count	5	−142.5
M4	guided-practice hours + prior-preparation score	6	−141.9

Model	Terms	K	Log likelihood
	+ reflection-session count + a prespecified product term		

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add prior-preparation score	300.00
Step 1	add reflection-session count	303.20
Step 1	add the product term	306.40
Step 2	stop after M2	300.00
Step 2	add reflection-session count	295.00
Step 2	add the product term	297.80
Step 3	stop after M3	295.00
Step 3	add the product term	295.80

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

`T07-A05-V02`: Archive workflow and retrieval time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same retrieval time outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	checklist-practice sessions	3	−142.0
M2	checklist-practice sessions + archive-experience months	4	−134.0
M3	checklist-practice sessions + archive-experience months + catalog-familiarity score	5	−133.4
M4	checklist-practice sessions + archive-experience months + catalog-familiarity score + a prespecified product term	6	−131.8

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add archive-experience months	276.00
Step 1	add catalog-familiarity score	279.20
Step 1	add the product term	282.40
Step 2	stop after M2	276.00
Step 2	add catalog-familiarity score	276.80
Step 2	add the product term	279.60
Step 3	stop after M3	276.80
Step 3	add the product term	275.60

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

`T07-A05-V03`: Reading routines and comprehension

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same comprehension score outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	weekly reading hours	3	−180.0
M2	weekly reading hours + baseline-vocabulary score	4	−170.0
M3	weekly reading hours + baseline-vocabulary score + annotation-session count	5	−166.0
M4	weekly reading hours + baseline-vocabulary score + annotation-session count + a prespecified product term	6	−165.5

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add baseline-vocabulary score	348.00
Step 1	add annotation-session count	351.20
Step 1	add the product term	354.40
Step 2	stop after M2	348.00
Step 2	add annotation-session count	342.00
Step 2	add the product term	344.80
Step 3	stop after M3	342.00
Step 3	add the product term	343.00

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

`T07-A05-V04`: Route rehearsal and navigation time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same navigation time outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	route-rehearsal attempts	3	−130.0
M2	route-rehearsal attempts + route-familiarity score	4	−126.0
M3	route-rehearsal attempts + route-familiarity score + landmark-recall score	5	−125.5
M4	route-rehearsal attempts + route-familiarity score + landmark-recall score + a prespecified product term	6	−125.2

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add route-familiarity score	260.00
Step 1	add landmark-recall score	263.20
Step 1	add the product term	266.40
Step 2	stop after M2	260.00

Forward step	Candidate action	AIC
Step 2	add landmark-recall score	261.00
Step 2	add the product term	263.80
Step 3	stop after M3	261.00
Step 3	add the product term	262.40

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

`T07-A05-V05`: Search practice and catalog accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same catalog-accuracy score outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	search-practice sets	3	−200.0
M2	search-practice sets + prior catalog-knowledge score	4	−188.0
M3	search-practice sets + prior catalog-knowledge score + query-planning score	5	−183.0
M4	search-practice sets + prior catalog-knowledge score + query-planning score + a prespecified product term	6	−180.0

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add prior catalog-knowledge score	384.00
Step 1	add query-planning score	387.20
Step 1	add the product term	390.40
Step 2	stop after M2	384.00
Step 2	add query-planning score	376.00
Step 2	add the product term	378.80
Step 3	stop after M3	376.00

Forward step	Candidate action	AIC
Step 3	add the product term	372.00

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

`T07-A05-V06`: Workshop participation and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same confidence score outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	workshop sessions	3	−165.0
M2	workshop sessions + baseline-confidence score	4	−157.0
M3	workshop sessions + baseline-confidence score + reflection-log count	5	−156.4
M4	workshop sessions + baseline-confidence score + reflection-log count + a prespecified product term	6	−155.8

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add baseline-confidence score	322.00
Step 1	add reflection-log count	325.20
Step 1	add the product term	328.40
Step 2	stop after M2	322.00
Step 2	add reflection-log count	322.80
Step 2	add the product term	325.60
Step 3	stop after M3	322.80
Step 3	add the product term	323.60

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

T07-A05-V07: Focus blocks and task accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same task-accuracy score outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	notification-free blocks	3	−175.0
M2	notification-free blocks + sleep duration in hours	4	−166.0
M3	notification-free blocks + sleep duration in hours + planning-break count	5	−162.0
M4	notification-free blocks + sleep duration in hours + planning-break count + a prespecified product term	6	−161.2

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add sleep duration in hours	340.00
Step 1	add planning-break count	343.20
Step 1	add the product term	346.40
Step 2	stop after M2	340.00
Step 2	add planning-break count	334.00
Step 2	add the product term	336.80
Step 3	stop after M3	334.00
Step 3	add the product term	334.40

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

T07-A05-V08: Museum engagement and historical knowledge

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same historical-knowledge score outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	museum visits	3	−145.0
M2	museum visits + prior-history score	4	−140.0
M3	museum visits + prior-history score + exhibit-note count	5	−138.0
M4	museum visits + prior-history score + exhibit-note count + a prespecified product term	6	−136.4

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add prior-history score	288.00
Step 1	add exhibit-note count	291.20
Step 1	add the product term	294.40
Step 2	stop after M2	288.00
Step 2	add exhibit-note count	286.00
Step 2	add the product term	288.80
Step 3	stop after M3	286.00
Step 3	add the product term	284.80

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

`T07-A05-V09`: Peer feedback and revision quality

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same revision-quality score outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	peer-feedback rounds	3	−190.0
M2	peer-feedback rounds + baseline-writing score	4	−181.0

Model	Terms	K	Log likelihood
M3	peer-feedback rounds + baseline-writing score + revision-plan score	5	−180.3
M4	peer-feedback rounds + baseline-writing score + revision-plan score + a prespecified product term	6	−179.9

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add baseline-writing score	370.00
Step 1	add revision-plan score	373.20
Step 1	add the product term	376.40
Step 2	stop after M2	370.00
Step 2	add revision-plan score	370.60
Step 2	add the product term	373.40
Step 3	stop after M3	370.60
Step 3	add the product term	371.80

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

`T07-A05-V10`: Planning sessions and completion time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Four constructed, prespecified candidate models use exactly the same cases and the same completion time outcome. Here $\log(L)$ is the maximized log likelihood reported by the fitted model. Under the stated convention, K counts all estimated parameters used in the AIC calculation.

Model	Terms	K	Log likelihood
M1	planning sessions	3	−158.0
M2	planning sessions + task-complexity score	4	−149.0
M3	planning sessions + task-complexity score + progress-check count	5	−145.0
M4	planning sessions + task-complexity score +	6	−144.4

Model	Terms	K	Log likelihood
	progress-check count + a prespecified product term		

(a) Calculate $AIC = -2\log(L) + 2K$ for every model and calculate each $\Delta AIC = AIC - AIC_{min}$. (b) Starting from M1, carry out forward selection with the step-specific candidate table below. At each step choose the lowest available AIC only if it is lower than the current model; otherwise stop.

Forward step	Candidate action	AIC
Step 1	add task-complexity score	306.00
Step 1	add progress-check count	309.20
Step 1	add the product term	312.40
Step 2	stop after M2	306.00
Step 2	add progress-check count	300.00
Step 2	add the product term	302.80
Step 3	stop after M3	300.00
Step 3	add the product term	300.80

(c) Plot the AIC path of the models actually selected, beginning with M1 at step 0. (d) Write the final model formula and interpret what the selected terms contribute to the fitted association. (e) Explain why the path is conditional on earlier choices and why the final model is not thereby proven true, causal, or externally predictive.

A07: Interpreting an Additive Group Model

`T07-A07-V01`: Tutorial support and reasoning

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for Self-guided and $G = 1$ for Tutored: $\hat{Y} = 42.00 + (3.00)X + (5.00)G$, where Y is reasoning score and X is practice hours.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 2.0$ and $X = 6.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

`T07-A07-V02`: Archive experience and retrieval

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for New staff and $G = 1$ for Experienced staff: $\hat{Y} = 36.00 + (-1.80)X + (-4.00)G$, where Y is retrieval time and X is practice sessions.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 1.0$ and $X = 5.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

T07-A07-V03: Reading format and comprehension

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for Print and $G = 1$ for Digital: $\hat{Y} = 51.00 + (2.20)X + (-2.50)G$, where Y is comprehension score and X is reading hours.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 2.0$ and $X = 7.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

T07-A07-V04: Route aid and navigation

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for Paper map and $G = 1$ for App map: $\hat{Y} = 44.00 + (-2.00)X + (-3.00)G$, where Y is navigation time and X is rehearsal attempts.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 1.0$ and $X = 4.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

T07-A07-V05: Search guide and accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for No guide and $G = 1$ for Checklist: $\hat{Y} = 55.00 + (2.50)X + (4.00)G$, where Y is accuracy score and X is practice sets.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 0.0$ and $X = 4.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

T07-A07-V06: Workshop mode and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for Online and $G = 1$ for In person: $\hat{Y} = 38.00 + (3.20)X + (3.50)G$, where Y is confidence score and X is sessions attended.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 1.0$ and $X = 5.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

T07-A07-V07: Focus setting and accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for Shared room and $G = 1$ for Quiet room: $\hat{Y} = 60.00 + (1.70)X + (4.50)G$, where Y is task-accuracy score and X is focus blocks.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 2.0$ and $X = 8.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

`T07-A07-V08`: Museum guide and knowledge

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for Self-guided and $G = 1$ for Guided: $\hat{Y} = 47.00 + (4.00)X + (6.00)G$, where Y is knowledge score and X is visits.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 0.0$ and $X = 3.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

`T07-A07-V09`: Feedback mode and revision

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for Written and $G = 1$ for Conversation: $\hat{Y} = 52.00 + (3.50)X + (2.00)G$, where Y is revision score and X is feedback rounds.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 1.0$ and $X = 4.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

`T07-A07-V10`: Planning format and completion

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model uses $G = 0$ for Paper and $G = 1$ for Digital: $\hat{Y} = 70.00 + (-2.40)X + (-3.50)G$, where Y is completion time and X is planning sessions.

(a) Write the fitted equation for each group and interpret the intercept at $X = 0$, noting when zero may be only a mathematical reference. (b) Interpret the common X slope and the group coefficient as conditional comparisons. (c) Calculate the fitted coordinates for both groups at $X = 1.0$ and $X = 6.0$ and organize them in a table. (d) Explain how those coordinates show parallel lines and a constant group gap, and state why the fitted gap alone does not establish a causal group effect.

A08: Releveling Without Changing Fitted Relationships

`T07-A08-V01`: Practice format releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Independent and $G = 1$ for Partnered: $\hat{Y} = 40.00 + (2.80)X + (4.50)G$, where Y is reasoning score and X is practice hours. Recode with $H = 0$ for Partnered and $H = 1$ for Independent.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 1.0$ and $X = 5.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

T07-A08-V02: Archive role releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Assistant and $G = 1$ for Coordinator: $\hat{Y} = 35.00 + (-1.60)X + (-5.00)G$, where Y is retrieval time and X is practice sessions. Recode with $H = 0$ for Coordinator and $H = 1$ for Assistant.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 0.0$ and $X = 4.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

T07-A08-V03: Reading medium releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Print and $G = 1$ for Audio: $\hat{Y} = 50.00 + (2.00)X + (-3.00)G$, where Y is comprehension score and X is reading hours. Recode with $H = 0$ for Audio and $H = 1$ for Print.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 2.0$ and $X = 6.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

T07-A08-V04: Navigation display releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Static and $G = 1$ for Interactive: $\hat{Y} = 46.00 + (-2.20)X + (-4.00)G$, where Y is navigation time and X is rehearsal attempts. Recode with $H = 0$ for Interactive and $H = 1$ for Static.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 1.0$ and $X = 5.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

T07-A08-V05: Catalog aid releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Index and $G = 1$ for Search bar: $\hat{Y} = 53.00 + (2.60)X + (3.00)G$, where Y is accuracy score and X is practice sets. Recode with $H = 0$ for Search bar and $H = 1$ for Index.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 0.0$ and $X = 3.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

T07-A08-V06: Workshop setting releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Remote and $G = 1$ for Classroom: $\hat{Y} = 37.00 + (3.00)X + (5.00)G$, where Y is confidence score and X is sessions. Recode with $H = 0$ for Classroom and $H = 1$ for Remote.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 1.0$ and $X = 4.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

T07-A08-V07: Focus room releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Open room and $G = 1$ for Private room: $\hat{Y} = 59.00 + (1.80)X + (4.00)G$, where Y is task-accuracy score and X is focus blocks. Recode with $H = 0$ for Private room and $H = 1$ for Open room.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 2.0$ and $X = 7.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

T07-A08-V08: Museum route releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Free route and $G = 1$ for Curated route: $\hat{Y} = 45.00 + (4.20)X + (6.50)G$, where Y is knowledge score and X is visits. Recode with $H = 0$ for Curated route and $H = 1$ for Free route.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 0.0$ and $X = 3.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

T07-A08-V09: Revision meeting releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Asynchronous and $G = 1$ for Live: $\hat{Y} = 51.00 + (3.40)X + (2.50)G$, where Y is revision score and X is feedback rounds. Recode with $H = 0$ for Live and $H = 1$ for Asynchronous.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 1.0$ and $X = 5.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

`T07-A08-V10`: Planning tool releveling

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed additive model codes $G = 0$ for Notebook and $G = 1$ for Calendar: $\hat{Y} = 72.00 + (-2.50)X + (-4.00)G$, where Y is completion time and X is planning sessions. Recode with $H = 0$ for Calendar and $H = 1$ for Notebook.

(a) Derive the new intercept, X slope, and coefficient on H. (b) Write both group equations under the new coding and interpret the new group coefficient. (c) At $X = 1.0$ and $X = 6.0$, calculate fitted values from both parameterizations for both groups and place them side by side. (d) Use the calculations to explain why releveling changes the coefficient coordinate system but cannot change fitted values, residuals, or group-specific fitted lines.

A09: Interpreting a Group-by-Quantitative-Predictor Interaction

`T07-A09-V01`: Practice hours by tutorial support

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Self-guided, $G = 1$ for Tutored, and the product XG: $\hat{Y} = 40.00 + (2.00)X + (4.00)G + (1.20)XG$. Here Y is reasoning score and X is practice hours.

(a) Construct rows for both groups at $X = 1.0$ and $X = 5.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V02`: Practice sessions by archive role

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for New staff, $G = 1$ for Experienced staff, and the product XG: $\hat{Y} = 38.00 + (-1.20)X + (-3.00)G + (-0.80)XG$. Here Y is retrieval time and X is practice sessions.

(a) Construct rows for both groups at $X = 0.0$ and $X = 4.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V03`: Reading hours by medium

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Print, $G = 1$ for Audio, and the product XG: $\hat{Y} = 49.00 + (2.60)X + (2.00)G + (-1.00)XG$. Here Y is comprehension score and X is reading hours.

(a) Construct rows for both groups at $X = 2.0$ and $X = 6.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V04`: Rehearsal by navigation display

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Static, $G = 1$ for Interactive, and the product XG: $\hat{Y} = 48.00 + (-1.50)X + (-2.00)G + (-0.90)XG$. Here Y is navigation time and X is rehearsal attempts.

(a) Construct rows for both groups at $X = 1.0$ and $X = 5.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V05`: Practice sets by catalog aid

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Index, $G = 1$ for Search bar, and the product XG: $\hat{Y} = 52.00 + (2.00)X + (3.00)G + (0.70)XG$. Here Y is accuracy score and X is practice sets.

(a) Construct rows for both groups at $X = 0.0$ and $X = 4.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V06`: Sessions by workshop setting

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Remote, $G = 1$ for Classroom, and the product XG: $\hat{Y} = 36.00 + (2.40)X + (5.00)G + (0.80)XG$. Here Y is confidence score and X is sessions.

(a) Construct rows for both groups at $X = 1.0$ and $X = 5.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V07`: Focus blocks by room type

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Open room, $G = 1$ for Private room, and the product XG: $\hat{Y} = 58.00 + (2.10)X + (4.00)G + (-0.60)XG$. Here Y is task-accuracy score and X is focus blocks.

(a) Construct rows for both groups at $X = 2.0$ and $X = 7.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V08`: Visits by museum route

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Free route, $G = 1$ for Curated route, and the product XG: $\hat{Y} = 44.00 + (3.50)X + (3.00)G + (1.50)XG$. Here Y is knowledge score and X is visits.

(a) Construct rows for both groups at $X = 0.0$ and $X = 3.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V09`: Feedback rounds by meeting mode

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Asynchronous, $G = 1$ for Live, and the product XG: $\hat{Y} = 50.00 + (2.80)X + (4.00)G + (-0.50)XG$. Here Y is revision score and X is feedback rounds.

(a) Construct rows for both groups at $X = 1.0$ and $X = 5.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.

`T07-A09-V10`: Planning by tool type

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A constructed interaction model uses $G = 0$ for Notebook, $G = 1$ for Calendar, and the product XG: $\hat{Y} = 74.00 + (-1.80)X + (-2.00)G + (-0.90)XG$. Here Y is completion time and X is planning sessions.

(a) Construct rows for both groups at $X = 1.0$ and $X = 6.0$, showing G and XG. (b) Derive each group's conditional intercept and slope. (c) Calculate the four fitted coordinates and organize all quantities in one table. (d) Draw the two fitted lines from those coordinates in one labeled graph and mark the fitted group gap at both displayed X values. (e) Interpret b_1, b_2, and b_3 at their proper reference conditions, explain how b_3 changes the group gap across X, and state why an interaction is not itself causal evidence.