**Chapter 10 Exercises: Solutions**

1a. The between-school variance (τ00) is 35.142. ICC = 35.142 / (35.142 + 111.268) = .24. This indicates that 24% of the total variance is accounted for by schools in level 2.

1b.

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| . xtmixed mathach gender cbyses cusecalc cusecompu || SCH\_ID: , mle varPerforming EM optimization: Performing gradient-based optimization: Iteration 0: log likelihood = -52284.213 Iteration 1: log likelihood = -52284.213 Computing standard errors:Mixed-effects ML regression Number of obs = 14016Group variable: SCH\_ID Number of groups = 748 Obs per group: min = 2 avg = 18.7 max = 48 Wald chi2(4) = 3068.59Log likelihood = -52284.213 Prob > chi2 = 0.0000------------------------------------------------------------------------------ mathach | Coef. Std. Err. z P>|z| [95% Conf. Interval]-------------+---------------------------------------------------------------- gender | -1.815709 .1722734 -10.54 0.000 -2.153358 -1.478059 cbyses | 4.869302 .128413 37.92 0.000 4.617617 5.120987 cusecalc | 1.718787 .070792 24.28 0.000 1.580037 1.857537 cusecompu | -1.704341 .0697523 -24.43 0.000 -1.841053 -1.567629 \_cons | 221.1213 5.893306 37.52 0.000 209.5706 232.6719------------------------------------------------------------------------------------------------------------------------------------------------------------ Random-effects Parameters | Estimate Std. Err. [95% Conf. Interval]-----------------------------+------------------------------------------------SCH\_ID: Identity | var(\_cons) | 15.17136 1.124943 13.11924 17.54448-----------------------------+------------------------------------------------ var(Residual) | 94.69471 1.16553 92.43765 97.00688------------------------------------------------------------------------------LR test vs. linear regression: chibar2(01) = 895.94 Prob >= chibar2 = 0.0000 |

1c.

* The coefficient for gender is –1.816, *z* = –10.54, *p* < .001. This indicates that female students tend to have lower mathematics achievement than male students when holding other predictors constant.
* The coefficient for cbyses is 4.869, *z* = 37.92, *p* < .001. This indicates that students with higher SES tend to have better mathematics achievement.
* The coefficient for cusecalc is 1.719, *z* = 24.28, *p* < .001. This indicates that students who use calculators more frequently tend to have better mathematics achievement.
* The coefficient for cusecompu is –1.704, *z* = –24.43, *p* < .001. This indicates that students who use computers in class more frequently tend to have lower mathematics achievement.

1d.

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| . \* Log likelihood ratio test comparing the unconditional model and random-intercept model. lrtest null ranintLikelihood-ratio test LR chi2(4) = 2660.40(Assumption: null nested in ranint) Prob > chi2 = 0.0000 |

The log likelihood chi-square test χ2(4) = 2660.40, *p* < .001. This indicates that we are in favor of the random intercept model rather than the unconditional model.

1e.

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| . \*Contextual Model without Cross-Level Interactions (Model 3). xtmixed mathach gender cbyses cusecalc cusecompu urban || SCH\_ID: cbyses, cov(uns) mle varPerforming EM optimization: Performing gradient-based optimization: Iteration 0: log likelihood = -52282.052 (not concave)Iteration 1: log likelihood = -52281.988 (backed up)Iteration 2: log likelihood = -52280.291 (backed up)Iteration 3: log likelihood = -52278.11 Iteration 4: log likelihood = -52277.686 Iteration 5: log likelihood = -52277.644 Iteration 6: log likelihood = -52277.644 Computing standard errors:Mixed-effects ML regression Number of obs = 14016Group variable: SCH\_ID Number of groups = 748 Obs per group: min = 2 avg = 18.7 max = 48 Wald chi2(5) = 2848.02Log likelihood = -52277.644 Prob > chi2 = 0.0000------------------------------------------------------------------------------ mathach | Coef. Std. Err. z P>|z| [95% Conf. Interval]-------------+---------------------------------------------------------------- gender | -1.819236 .1722028 -10.56 0.000 -2.156747 -1.481725 cbyses | 4.865067 .1368798 35.54 0.000 4.596788 5.133347 cusecalc | 1.713907 .0707514 24.22 0.000 1.575237 1.852577 cusecompu | -1.703282 .0697006 -24.44 0.000 -1.839893 -1.566671 urban | -.7858608 .3543744 -2.22 0.027 -1.480422 -.0912998 \_cons | 221.0436 6.173422 35.81 0.000 208.944 233.1433------------------------------------------------------------------------------------------------------------------------------------------------------------ Random-effects Parameters | Estimate Std. Err. [95% Conf. Interval]-----------------------------+------------------------------------------------SCH\_ID: Unstructured | var(cbyses) | 1.453387 .6549564 .6008897 3.515345 var(\_cons) | 2195.746 958.5577 933.2292 5166.257 cov(cbyses,\_cons) | 56.30534 25.04834 7.211492 105.3992-----------------------------+------------------------------------------------ var(Residual) | 94.06641 1.18492 91.77244 96.41771------------------------------------------------------------------------------LR test vs. linear regression: chi2(3) = 894.70 Prob > chi2 = 0.0000Note: LR test is conservative and provided only for reference. |

1f. Level 1 and level 2 equations for the contextual model are as follows:

Level 1: *Y*ij = β0j + β1jgenderij + β2jcbysesij + β3jcusecalcij + β4jcusecompuij + *r*ij

Level 2: β0j = γ00 + γ01urbanj + *u*0j

 β1j = γ10

 β2j = γ20 + *u*2j

 β3j = γ30

 β4j = γ40

1g. The coefficient for urban is –.786, *z* = –2.22, *p* < .001. This indicates that students’ mathematics scores in urban schools tend to be lower than those in suburban or rural schools.

1h. Comparing the random intercept model (Model 2) and the contextual model (Model 3), the log likelihood chi-square χ2(3) = 13.14, *p* < .01. This indicates that the contextual model fits the data better. Therefore, among all three models, the contextual model fits the data best.

2a. The between-school variance (τ00) is 1.061. ICC = τ00 / ( τ00+ π2 / 3) = 1.061 / (1.061 + 3.29) = .244. This indicates that 24.4% of the total variance is accounted for by schools in level 2.

2b.

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| . \* Random-intercept model (Model 2). melogit Profmath2 gender cbyses cusecalc || SCH\_ID: Fitting fixed-effects model:Iteration 0: log likelihood = -7817.2872 Iteration 1: log likelihood = -7804.5025 Iteration 2: log likelihood = -7804.4829 Iteration 3: log likelihood = -7804.4829 Refining starting values:Grid node 0: log likelihood = -7625.0667Fitting full model:Iteration 0: log likelihood = -7625.0667 Iteration 1: log likelihood = -7594.2264 Iteration 2: log likelihood = -7590.696 Iteration 3: log likelihood = -7590.6906 Iteration 4: log likelihood = -7590.6906 Mixed-effects logistic regression Number of obs = 14489Group variable: SCH\_ID Number of groups = 748 Obs per group: min = 2 avg = 19.4 max = 50Integration method: mvaghermite Integration points = 7 Wald chi2(3) = 1128.08Log likelihood = -7590.6906 Prob > chi2 = 0.0000------------------------------------------------------------------------------ Profmath2 | Coef. Std. Err. z P>|z| [95% Conf. Interval]-------------+---------------------------------------------------------------- gender | -.2092116 .0424109 -4.93 0.000 -.2923354 -.1260878 cbyses | .9386669 .0341039 27.52 0.000 .8718244 1.005509 cusecalc | .2888555 .0163893 17.62 0.000 .2567331 .3209779 \_cons | .8359557 .0719147 11.62 0.000 .6950056 .9769059-------------+----------------------------------------------------------------SCH\_ID | var(\_cons)| .5275772 .0516531 .4354598 .6391811------------------------------------------------------------------------------LR test vs. logistic regression: chibar2(01) = 427.58 Prob>=chibar2 = 0.0000. melogit, orMixed-effects logistic regression Number of obs = 14489Group variable: SCH\_ID Number of groups = 748 Obs per group: min = 2 avg = 19.4 max = 50Integration method: mvaghermite Integration points = 7 Wald chi2(3) = 1128.08Log likelihood = -7590.6906 Prob > chi2 = 0.0000------------------------------------------------------------------------------ Profmath2 | Odds Ratio Std. Err. z P>|z| [95% Conf. Interval]-------------+---------------------------------------------------------------- gender | .8112236 .0344047 -4.93 0.000 .7465181 .8815375 cbyses | 2.556571 .0871891 27.52 0.000 2.39127 2.733299 cusecalc | 1.334899 .021878 17.62 0.000 1.2927 1.378475 \_cons | 2.307018 .1659084 11.62 0.000 2.00372 2.656225-------------+----------------------------------------------------------------SCH\_ID | var(\_cons)| .5275772 .0516531 .4354598 .6391811------------------------------------------------------------------------------LR test vs. logistic regression: chibar2(01) = 427.58 Prob>=chibar2 = 0.0000 |

2c.

* OR for gender is .811, *p* < .001. This indicates that the odds of being proficient in math level 2 for female students are .811 times as great as the odds for male students when holding other predictors constant.
* OR for cbyses is 2.557, *p* < .001. This indicates that a one-unit increase in SES is associated with a 2.557-point increase in the odds of being proficient in math.
* OR for cusecalc is 1.335, *p* < .001. This indicates that a one-unit increase in using calculators corresponds to a 1.335-point increase in the odds of being proficient in math.

2d.

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| . \* Log likelihood ratio test. lrtest binull biranintLikelihood-ratio test LR chi2(3) = 1223.91(Assumption: binull nested in biranint) Prob > chi2 = 0.0000 |

The log likelihood chi-square test χ2(3) = 1223.91, *p* < .001. This indicates that the random intercept model fits the data better than the unconditional model.

2e.

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| . \*Contextual Model without Cross-Level Interactions (Model 3). melogit Profmath2 gender cbyses cusecalc urban || SCH\_ID: cusecalc, cov(uns) Fitting fixed-effects model:Iteration 0: log likelihood = -7810.3866 Iteration 1: log likelihood = -7797.9465 Iteration 2: log likelihood = -7797.9276 Iteration 3: log likelihood = -7797.9276 Refining starting values:Grid node 0: log likelihood = -8142.6955Fitting full model:Iteration 0: log likelihood = -8142.6955 (not concave)Iteration 1: log likelihood = -7961.206 (not concave)Iteration 2: log likelihood = -7880.7964 (not concave)Iteration 3: log likelihood = -7710.8561 (not concave)Iteration 4: log likelihood = -7657.3979 (not concave)Iteration 5: log likelihood = -7635.8268 Iteration 6: log likelihood = -7588.8695 Iteration 7: log likelihood = -7582.8602 Iteration 8: log likelihood = -7582.6448 Iteration 9: log likelihood = -7582.6439 Iteration 10: log likelihood = -7582.6439 Mixed-effects logistic regression Number of obs = 14489Group variable: SCH\_ID Number of groups = 748 Obs per group: min = 2 avg = 19.4 max = 50Integration method: mvaghermite Integration points = 7 Wald chi2(4) = 1046.09Log likelihood = -7582.6439 Prob > chi2 = 0.0000------------------------------------------------------------------------------------ Profmath2 | Coef. Std. Err. z P>|z| [95% Conf. Interval]-------------------+---------------------------------------------------------------- gender | -.211156 .0428014 -4.93 0.000 -.2950451 -.1272668 cbyses | .9473031 .0344271 27.52 0.000 .8798273 1.014779 cusecalc | .2880099 .0188632 15.27 0.000 .2510387 .324981 urban | -.1559216 .0735161 -2.12 0.034 -.3000106 -.0118327 \_cons | .8929021 .0843149 10.59 0.000 .7276478 1.058156-------------------+----------------------------------------------------------------SCH\_ID | var(cusecalc)| .0321336 .0119069 .0155436 .0664303 var(\_cons)| 1.011696 .1983427 .6889256 1.485689-------------------+----------------------------------------------------------------SCH\_ID |cov(\_cons,cusecalc)| -.1283152 .045329 -2.83 0.005 -.2171585 -.0394719------------------------------------------------------------------------------------LR test vs. logistic regression: chi2(3) = 430.57 Prob > chi2 = 0.0000Note: LR test is conservative and provided only for reference.. melogit, orMixed-effects logistic regression Number of obs = 14489Group variable: SCH\_ID Number of groups = 748 Obs per group: min = 2 avg = 19.4 max = 50Integration method: mvaghermite Integration points = 7 Wald chi2(4) = 1046.09Log likelihood = -7582.6439 Prob > chi2 = 0.0000------------------------------------------------------------------------------------ Profmath2 | Odds Ratio Std. Err. z P>|z| [95% Conf. Interval]-------------------+---------------------------------------------------------------- gender | .8096478 .034654 -4.93 0.000 .744498 .8804987 cbyses | 2.578746 .0887787 27.52 0.000 2.410483 2.758754 cusecalc | 1.33377 .0251592 15.27 0.000 1.28536 1.384004 urban | .8556262 .0629023 -2.12 0.034 .7408104 .988237 \_cons | 2.442207 .2059145 10.59 0.000 2.070205 2.881054-------------------+----------------------------------------------------------------SCH\_ID | var(cusecalc)| .0321336 .0119069 .0155436 .0664303 var(\_cons)| 1.011696 .1983427 .6889256 1.485689-------------------+----------------------------------------------------------------SCH\_ID |cov(\_cons,cusecalc)| -.1283152 .045329 -2.83 0.005 -.2171585 -.0394719------------------------------------------------------------------------------------LR test vs. logistic regression: chi2(3) = 430.57 Prob > chi2 = 0.0000Note: LR test is conservative and provided only for reference. |

2f. Level 1 and level 2 equations for the contextual model are as follows:

Level 1: logit [(*x*ij)] = β0j + β1jgenderij + β2jcbysesij + β3jcusecalcij

Level 2: β0j = γ00 + γ01urbanj + *u*0j

 β1j = γ10

 β2j = γ20

 β3j = γ30 + *u*3j

2g. OR for urban is .856, *p* < .001. This indicates that the odds of being proficient in math level 2 for students in urban schools are .856 times as great as the odds for students in suburban or rural schools when holding other predictors constant.

2h. Comparing the random intercept model (Model 2) and the contextual model (Model 3), the log likelihood chi-square χ2(3) = 16.09, *p* < .01. This indicates that the contextual model fits the data better. Therefore, among all three models, the contextual model fits the data best.