

Supplemental Material

CBE—Life Sciences Education

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Supplemental Material

The first section of this supplemental material describes the demographic patterns uncovered that are not directly related to the impact of pre-class RQ on students. The second section summarizes each best fit model and the decomposed R^2 for each factor or collection of factors. The third section contains tables of parameter estimates, confidence intervals and p-values and plots of marginal effects for the best fit models for each response variable, organized by research question.

Section 1

Students who had higher GPAs performed better on in-class RQs than students who had lower GPAs. GPA explained 21% of the variation in mean in-class RQ score; a large effect size. Additionally, males and students who felt more prepared for in-class RQs scored more points on in-class RQs. However, these factors only explained 0.6% and 4.2% of the variation, respectively; both small effect sizes.

Students who had higher GPAs also performed better on exams than students who had lower GPAs. GPA explained 49.6% of the variation in exam score; a large effect size. Additionally, males, students who completed more pre-class RQ assignments and students who had higher in-class RQ scores had higher exam scores (see supplemental material for parameter estimates and marginal effects plots). However, these three factors only explained an additional 0.4%, 0.2% and 7.1% of the variation, respectively; all small effect sizes.

While mean preparedness for in-class RQs and total exam points were retained in the best model, combined they only explain 5.7% of the variation of course enjoyment; a small effect size.

Section 2

Models, R^2 and ΔAIC^1 for each best fit analysis models. Under each model that retains treatment is the decomposed R^2 for each factor or collection of factors.

| Research Question | Model | R^2 | ΔAIC |
|-------------------|---|-------|--------------|
| Question 1 | Mean in-class RQ score ~ Gender + Preparedness + GPA | 0.258 | 166 |
| | Gender | 0.006 | |
| | Preparedness | 0.042 | |
| | GPA | 0.210 | |
| Question 2 | Total exam points ~ Gender + Number of pre-class RQ completed + Mean In-class RQ score + GPA + (1 Lecture section) | 0.573 | 498 |
| | Gender | 0.004 | |
| | Number of pre-class RQ completed | 0.002 | |
| | In-class RQ Score | 0.071 | |
| | GPA | 0.496 | |
| Question 3i | Compare RQ ~ Treatment + Preparedness + Treatment*Preparedness | 0.025 | 6 |
| Question 3i | Post Resource Value ~ Pre Resource Value + Resource Type + Resource Type*Pre Resource Value + Treatment + GPA + Treatment*GPA + Resource Type*GPA | 0.301 | 793 |
| | Pre Value + Resource Type + Resource Type*Pre Resource Value | 0.290 | |
| | Treatment + GPA + Treatment*GPA + | 0.011 | |

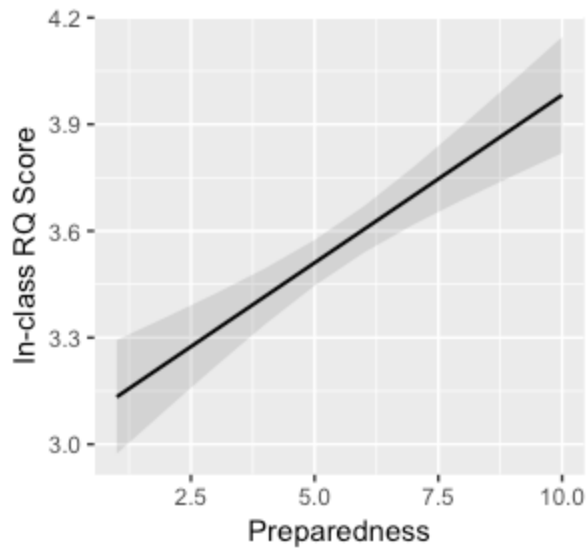
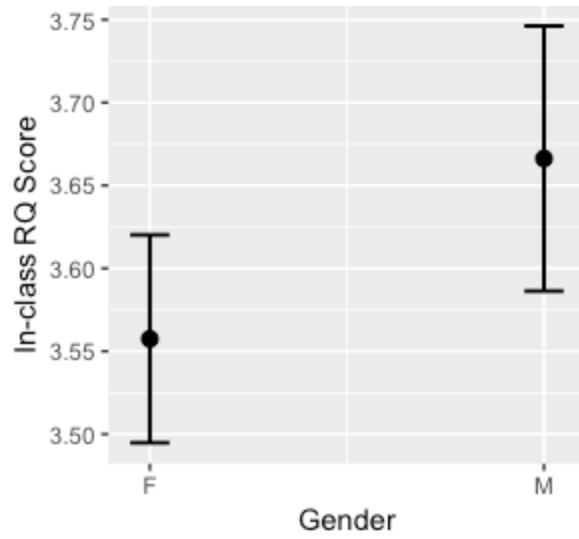
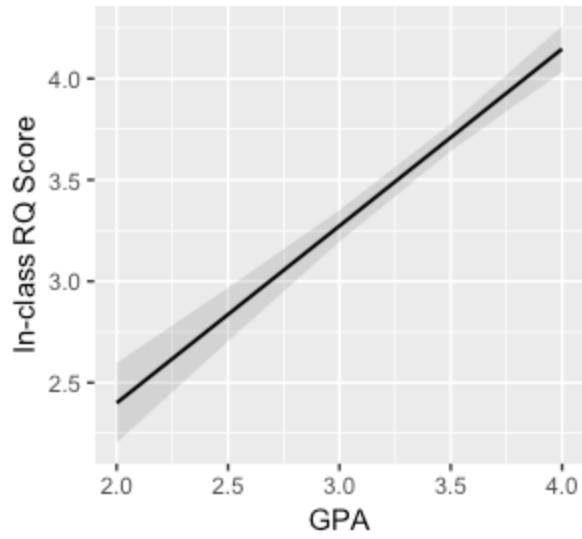
| | Resource Type*GPA | | |
|--------------|--|-------|----|
| Question 3ii | Enjoying course ~ Preparedness + Total exam points | 0.057 | 26 |
| | Preparedness | 0.020 | |
| | Total exam points | 0.029 | |

¹ Δ AIC is the difference between the best fit model and the null model. This difference is a measure of the relative goodness of fit the “best fit model” when compared to the null model. The null model is a model that only contains the intercepts, and any retained random effects. The null model is similar to the null hypothesis. The null model would be the best fit model if the proposed factors had no impact on the response variable.

Section 3

Question 1: Do gamified, adaptive reading quizzes improve students' preparedness for class?

| Mean in-class RQ score | | | |
|--|---------------|--------------|------------------|
| Predictors | Estimates | CI | p |
| (Intercept) | 0.13 | -0.36 – 0.62 | 0.591 |
| Gender (reference= female) | 0.11 | 0.01 – 0.21 | 0.036 |
| GPA | 0.87 | 0.73 – 1.01 | <0.001 |
| Mean preparedness | 0.09 | 0.06 – 0.13 | <0.001 |
| Observations | 575 | | |
| R ² / R ² adjusted | 0.258 / 0.254 | | |



Mean preparedness

| <i>Predictors</i> | <i>Estimates</i> | <i>CI</i> | <i>p</i> |
|-------------------|------------------|-------------|------------------|
| (Intercept) | 5.50 | 5.32 – 5.68 | <0.001 |

Random Effects

| | |
|-----------------|------|
| σ^2 | 2.13 |
| T00 Lab section | 0.12 |

ICC 0.05

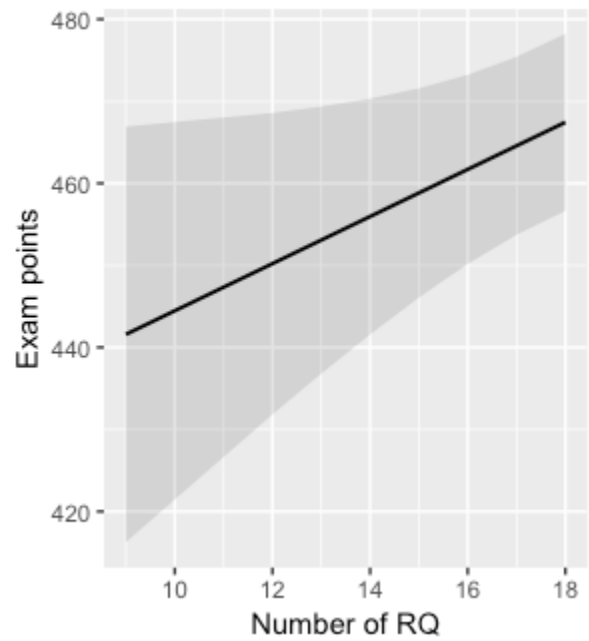
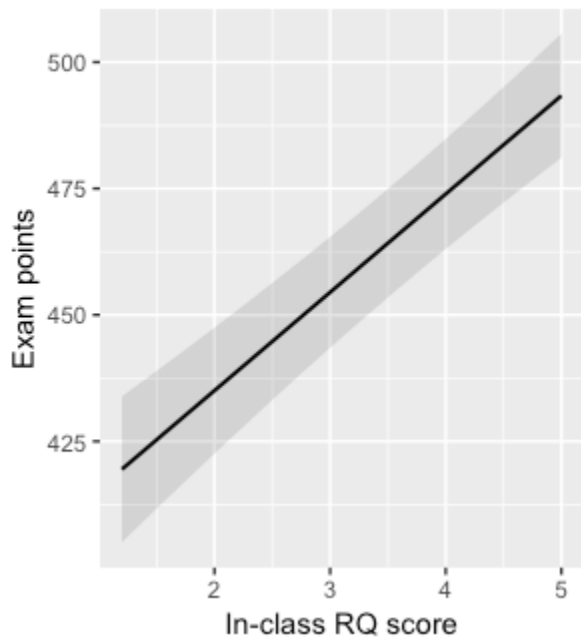
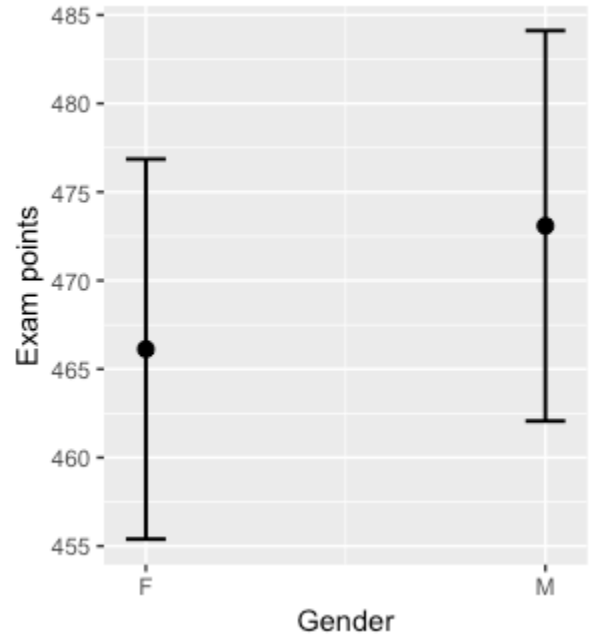
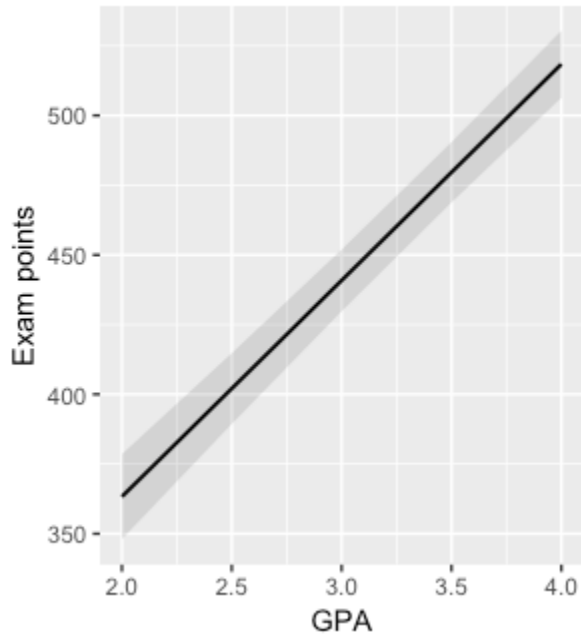
N Lab section 25

Observations 575

Marginal R² / Conditional R² 0.000 / 0.052

Question 2: Do gamified, adaptive reading quizzes improve students' exam performance?

| Total exam points | | | |
|--|------------------|----------------|------------------|
| <i>Predictors</i> | <i>Estimates</i> | <i>CI</i> | <i>p</i> |
| (Intercept) | 87.82 | 37.91 – 137.72 | 0.001 |
| Gender (reference=female) | 6.96 | 1.76 – 12.17 | 0.009 |
| GPA | 77.56 | 69.46 – 85.66 | <0.001 |
| Mean in-class RQ score | 19.44 | 15.35 – 23.53 | <0.001 |
| Number of RQ completed | 2.87 | 0.20 – 5.55 | 0.036 |
| Random Effects | | | |
| σ^2 | 945.53 | | |
| T00 Lecture section | 54.61 | | |
| ICC | 0.05 | | |
| N _{Lecture section} | 2 | | |
| Observations | 575 | | |
| Marginal R ² / Conditional R ² | 0.573 / 0.596 | | |



Question 3: Do gamified, adaptive reading quizzes positively impact students' perceptions of i) reading quizzes and ii) the course?

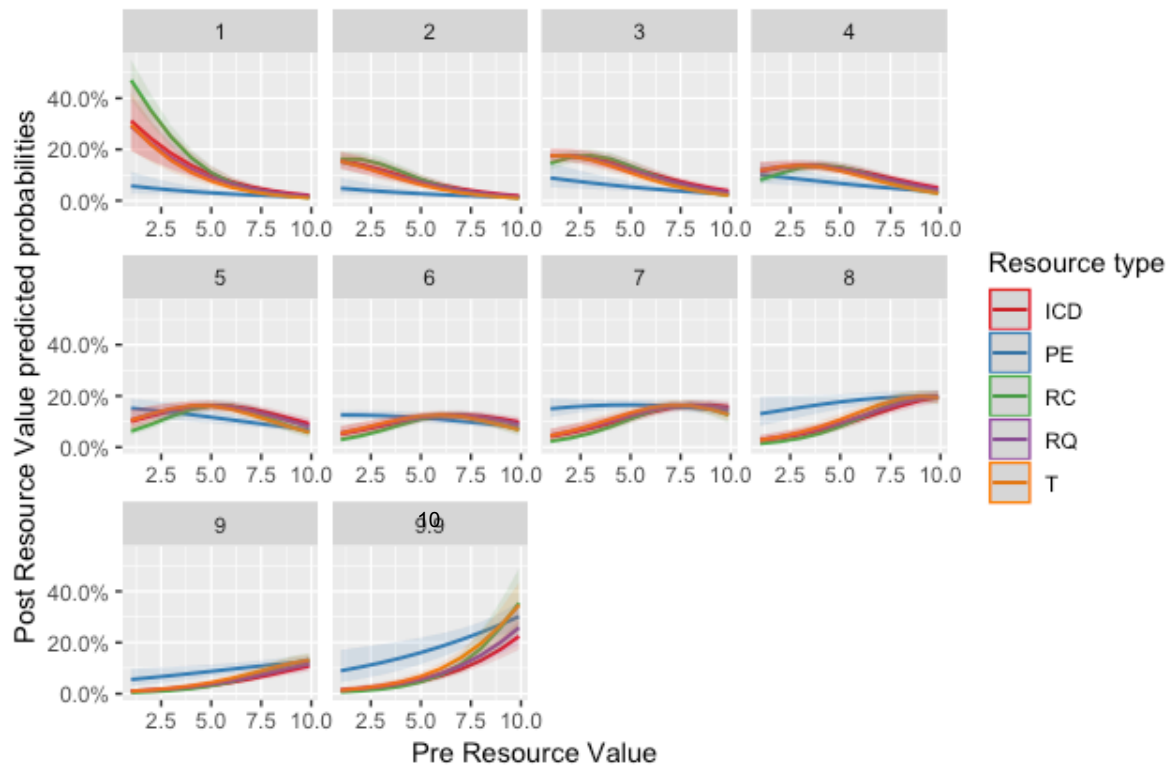
Resource types are abbreviated. ICD=In-class discussions, PE=practice exams, RC=random call, RQ=reading quizzes, T=textbook. The reference was in-class discussions.

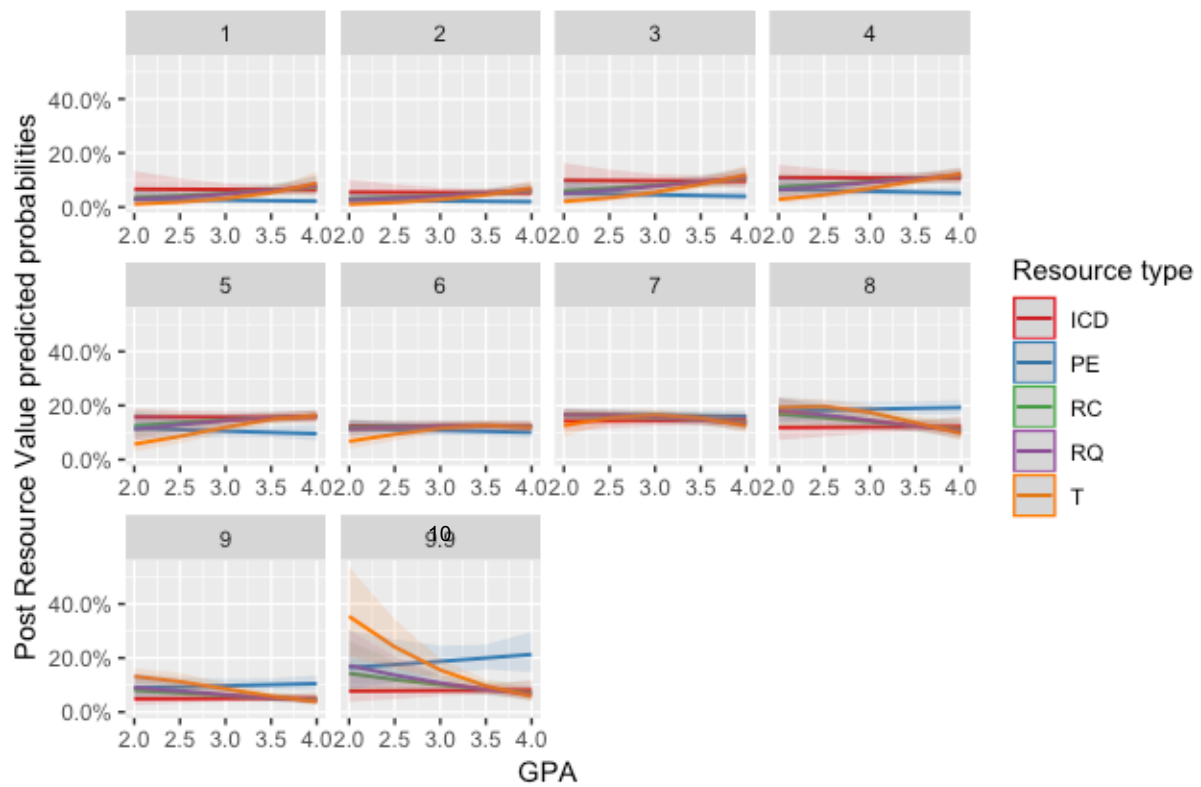
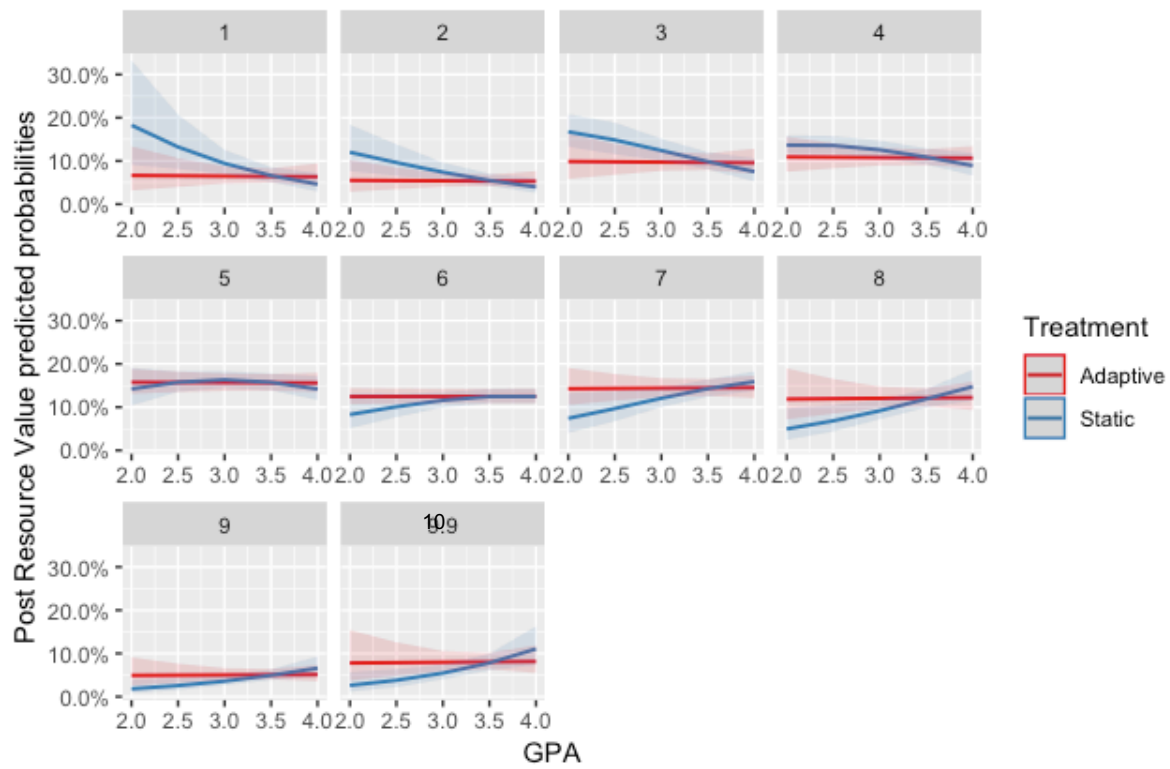
| Perceived Resource Value | | | |
|-------------------------------------|--------------------|----------------|------------------|
| <i>Predictors</i> | <i>Odds Ratios</i> | <i>CI</i> | <i>p</i> |
| (Intercept: 1 2) | 0.68 | 0.12 – 3.88 | 0.665 |
| (Intercept: 2 3) | 1.32 | 0.23 – 7.52 | 0.753 |
| (Intercept: 3 4) | 2.70 | 0.48 – 15.35 | 0.262 |
| (Intercept: 4 5) | 4.70 | 0.83 – 26.70 | 0.081 |
| (Intercept: 5 6) | 9.08 | 1.59 – 51.66 | 0.013 |
| (Intercept: 6 7) | 15.05 | 2.64 – 85.78 | 0.002 |
| (Intercept: 7 8) | 29.34 | 5.14 – 167.58 | <0.001 |
| (Intercept: 8 9) | 65.69 | 11.48 – 376.05 | <0.001 |
| (Intercept: 9 10) | 113.31 | 19.75 – 649.99 | <0.001 |
| RQ Treatment (reference = adaptive) | 0.07 | 0.02 – 0.27 | <0.001 |
| GPA | 1.02 | 0.64 – 1.64 | 0.919 |
| PE | 5.62 | 0.53 – 59.54 | 0.152 |
| RC | 1.73 | 0.18 – 16.21 | 0.631 |
| RQ | 7.23 | 0.75 – 69.62 | 0.087 |
| T | 41.15 | 4.15 – 408.23 | 0.001 |
| Pre Resource value | 1.41 | 1.30 – 1.53 | <0.001 |

| | | | |
|---|------|-------------|------------------|
| PE:Pre Resource value | 0.84 | 0.74 – 0.94 | 0.003 |
| RC:Pre Resource value | 1.16 | 1.04 – 1.30 | 0.008 |
| RQ:Pre Resource value | 1.01 | 0.90 – 1.13 | 0.858 |
| T:Pre Resource value | 1.06 | 0.95 – 1.19 | 0.308 |
| RQ Treatment (reference = adaptive):GPA | 2.10 | 1.41 – 3.12 | <0.001 |
| GPA:PE | 1.14 | 0.61 – 2.14 | 0.671 |
| GPA:RC | 0.66 | 0.35 – 1.23 | 0.187 |
| GPA:RQ | 0.57 | 0.31 – 1.05 | 0.070 |
| GPA:T | 0.33 | 0.18 – 0.61 | <0.001 |

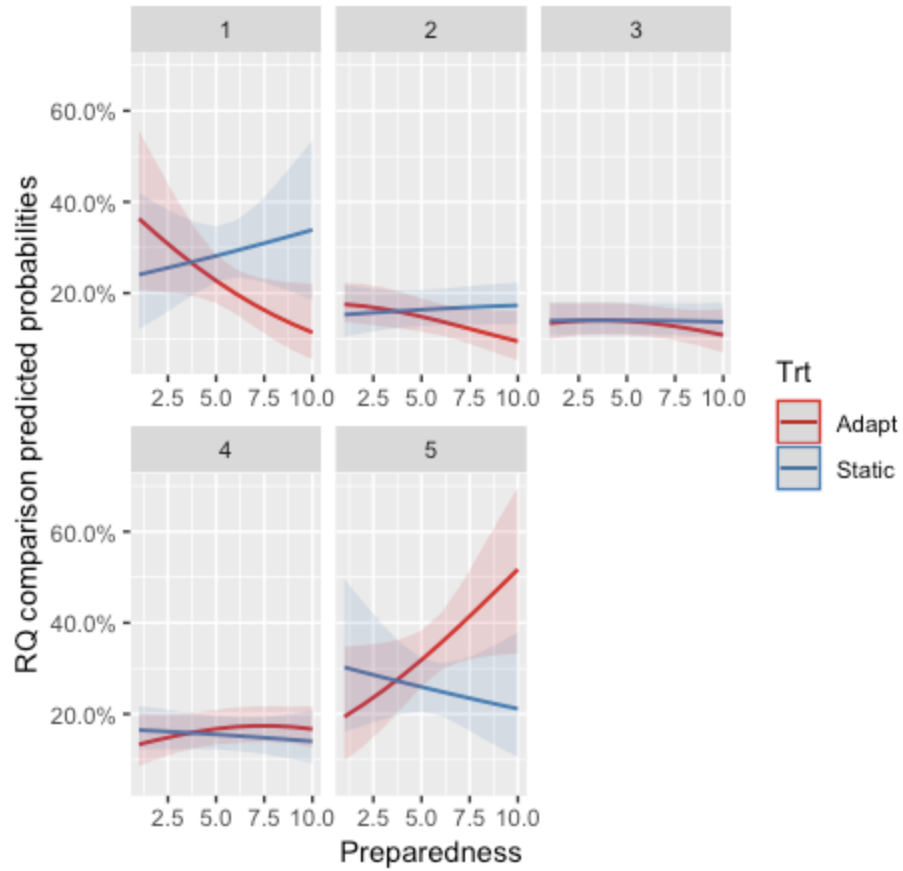
Observations 2552

Nagelkerke's R² 0.301





| Compare RQ | | | |
|---|--------------------|--------------|------------------|
| <i>Predictors</i> | <i>Odds Ratios</i> | <i>CI</i> | <i>p</i> |
| (Intercept: 1 2) | 0.67 | 0.30 – 1.53 | 0.345 |
| (Intercept: 2 3) | 1.38 | 0.61 – 3.12 | 0.443 |
| (Intercept: 3 4) | 2.42 | 1.07 – 5.51 | 0.035 |
| (Intercept: 4 5) | 4.90 | 2.14 – 11.23 | <0.001 |
| RQ Treatment (reference = adaptive) | 2.24 | 0.69 – 7.29 | 0.180 |
| ICRQ Prep | 1.18 | 1.02 – 1.36 | 0.022 |
| RQ Treatment (reference = adaptive):Mean preparedness | 0.80 | 0.65 – 0.99 | 0.037 |
| Observations | 514 | | |
| Nagelkerke's R ² | 0.025 | | |

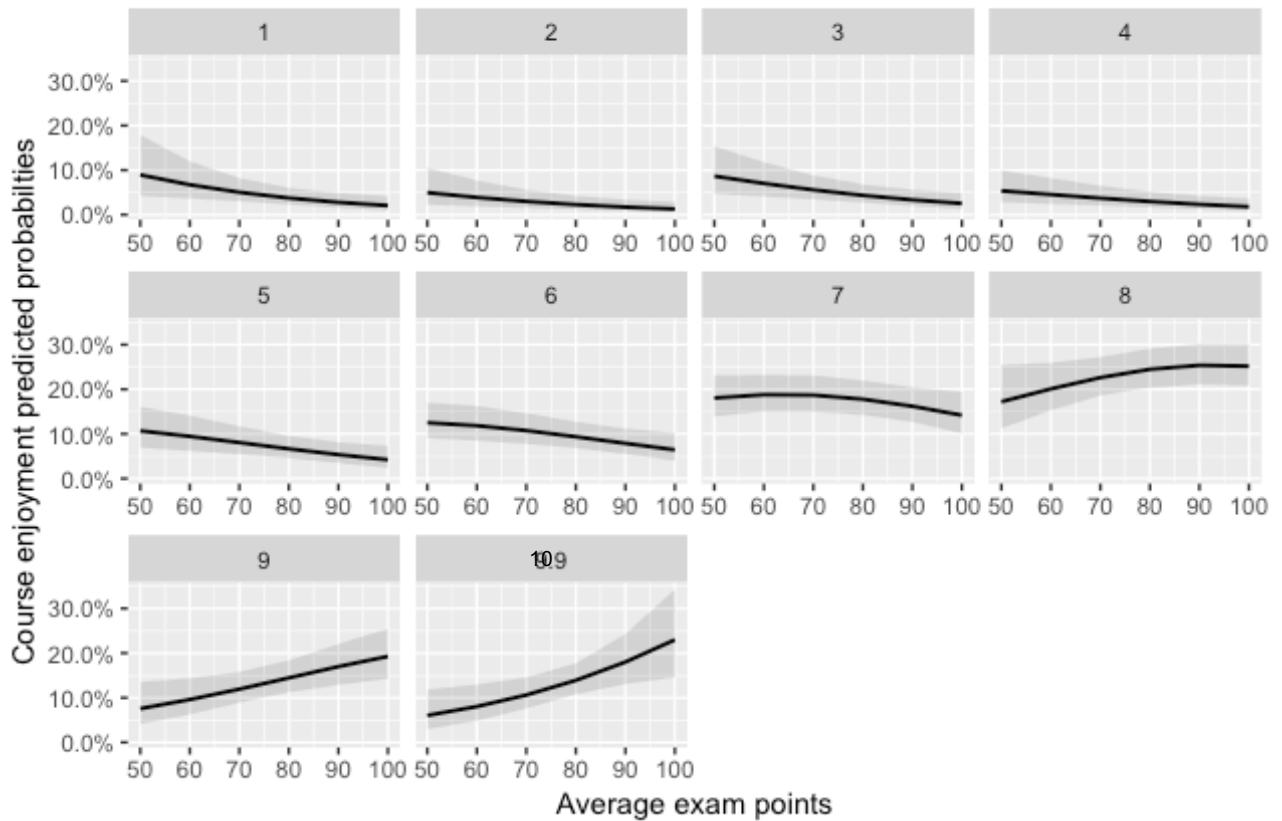


| Course enjoyment | | | |
|-------------------|--------------------|---------------|------------------|
| <i>Predictors</i> | <i>Odds Ratios</i> | <i>CI</i> | <i>p</i> |
| (Intercept: 1 2) | 1.52 | 0.30 – 7.60 | 0.612 |
| (Intercept: 2 3) | 2.50 | 0.51 – 12.28 | 0.260 |
| (Intercept: 3 4) | 4.51 | 0.92 – 21.98 | 0.063 |
| (Intercept: 4 5) | 6.00 | 1.23 – 29.22 | 0.027 |
| (Intercept: 5 6) | 9.74 | 1.99 – 47.54 | 0.005 |
| (Intercept: 6 7) | 16.19 | 3.30 – 79.46 | 0.001 |
| (Intercept: 7 8) | 34.75 | 7.00 – 172.43 | <0.001 |

| | | | |
|---------------------|--------|-----------------|------------------|
| (Intercept: 8 9) | 98.37 | 19.45 – 497.49 | <0.001 |
| (Intercept: 9 10) | 241.05 | 46.87 – 1239.70 | <0.001 |
| Average exam points | 1.03 | 1.01 – 1.05 | 0.003 |
| Preparedness | 1.24 | 1.11 – 1.38 | <0.001 |

Observations 514

Nagelkerke's R² 0.057



Predicted probabilities of EB 220 factor

