Determining an Appropriate Placement Test for Introductory Statistics: Preliminary Findings

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ECOTS 2022
Virtual Conference
2022-05-24

Context & Background

- Mount Saint Vincent University (MSVU) is a small, primarily undergraduate university in Atlantic Canada.
- MSVU has an existing placement test for precalculus and calculus but not for statistics.
- This study seeks to **determine an appropriate placement test** for statistics including the extent to which the existing placement test can be used for this purpose or adapted.
- Document validity evidence aligned with *Standards for Educational and Psychological Testing* (AERA et al., 2014)

This Presentation

- Is the existing math placement test predictive of statistics success?
  - Ordinal logistic regression
  - Comparison with results for precalculus
- What are the properties of the test and items?
  - Classical test theory (e.g., Crocker & Algina, 1986)
- What is an appropriate test blueprint for our statistics placement test?
  - Description of process
- All analyses performed using SPSS version 26 for macOS

Description of data

- Placement test data was collected from Fall 2019 through present.
- Demographic and course grade data were linked to placement test scores by the registrar's office.
- Some participants took both introductory statistics and Precalculus.
- *Limitations*: small sample size, and the placement test is usually only taken by students wishing to take precalculus or calculus

Characteristic	Intro. Stats	precalculus
Total Sample Size	106	52
Grade Not Available/In Progress	13	0
BIPOC Identifying	8.5%	21.2%
International	8.5%	23.1%
Women/non-binary	70.1%	78.8%
Accessibility Services	9.4%	11.5%
Age (mean)	21.29	21.65
Age (median)	20	20

Grade	Code
"Low Grade" F, D, C-, C, C+	0
B-	1
B	2
B+	3
A-	4
A	5
A+	6

Ordinal Logistic Regression Results: Intro. Stats

Grade	N	Marginal Percentage
0	9	18.0%
1	2	4.0%
2	5	10.0%
3	2	4.0%
4	7	14.0%
5	7	14.0%
6	18	36.0%
Valid N	50	100.0%

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	94.550	89	.324
Deviance	77.974	89	.792

Link function: Logit.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	120.364			
Final	109.729	10.635	1	.001

Link function: Logit.

Threshold/ Variable	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
[Grade = 0]	2.797	1.430	3.825	1	.050	-.006	5.600
[Grade = 1]	3.074	1.439	4.567	1	.033	.255	5.894
[Grade = 2]	3.678	1.465	6.300	1	.012	.806	6.551
[Grade = 3]	3.896	1.477	6.962	1	.008	1.002	6.790
[Grade = 4]	4.573	1.513	9.132	1	.003	1.607	7.539
[Grade = 5]	5.248	1.549	11.479	1	.001	2.212	8.285
ScoreA	.210	.068	9.680	1	.002	.078	.343

Warnings

There are 77 (68.8%) cells (i.e., dependent variable levels by observed combinations of predictor variable values) with zero frequencies.

Ordinal Logistic Regression Results: Precalculus

Grade	N	Marginal Percentage
0	15	28.8%
1	4	7.7%
2	2	3.8%
3	5	9.6%
4	5	9.6%
5	4	7.7%
6	17	32.7%
Valid N	52	100.0%

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	129.058	107	.072
Deviance	79.177	107	.980

Link function: Logit.

Threshold/ Variable	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
[Grade = 0]	2.638	.957	7.602	1	.006	.763	4.513
[Grade = 1]	3.086	.976	10.006	1	.002	1.174	4.999
[Grade = 2]	3.312	.988	11.247	1	.001	1.376	5.247
[Grade = 3]	3.870	1.023	14.321	1	.000	1.865	5.874
[Grade = 4]	4.437	1.064	17.389	1	.000	2.352	6.523
[Grade = 5]	4.883	1.099	19.730	1	.000	2.728	7.037
ScoreA	.224	.057	15.298	1	.000	.112	.336

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	129.574			
Final	110.637	18.937	1	.000

Link function: Logit.

Warnings

There are 95 (71.4%) cells (i.e., dependent variable levels by observed combinations of predictor variable values) with zero frequencies.

Results (Ordinal Logistic Regression)

- The probability of receiving a Low Grade decreases as placement test score increases. This was true for both introductory statistics and for precalculus.
  - Statistics: $logit(\hat{P}(Grade \leq 0)) = 2.797 - 0.210(ScoreA)$
  - Precalculus: $logit(\hat{P}(Grade \leq 0)) = 2.638 - 0.224(ScoreA)$
- There was strong evidence that the final model using the placement test score as a predictor was superior to the intercept only model for both introductory statistics ($\chi^2(1) = 10.635$, $p < .001$) and precalculus ($\chi^2(1) = 18.937$, $p < .000$)
- For a 1-point increase in the score on the placement test (ScoreA), we expect that that odds of getting a Low Grade (Grade = 0) will be 0.8 times greater than the odds of getting a Higher Grade (Grade > 0).
  - This applies to both intro. stats and precalculus.

Results (point biserial correlation)

Item	Correlation	Significance
1	.379**	.000
2	.396**	.000
3	.221**	.006
4	.336**	.000
5	.450**	.000
6	.384**	.000
7	.516**	.000
8	.420**	.000
9	.418**	.000
10	.333**	.000
11	.344**	.000
12	.275**	.001
13	.184*	.021
14	.409**	.000

Item	Correlation	Significance
15	.406**	.000
16	.302**	.000
17	.380**	.000
18	-.155	.053
19	.340**	.000
20	.079	.326
21	.353**	.000
22	.447**	.000
23	.534**	.000
24	.532**	.000
25	.539**	.000
26	.370**	.000
27	.419**	.000
28	.462**	.000
29	.144	.074

- This set of correlations indicates that item 13, 18, 20 and 29, which each have a correlation under 0.2 may be good candidates for removal from the placement test.
- Item 18 is negative, which may indicate miscoding, or that the item has poor fit.
- Overall, most items appear to be positively correlated with the overall test placement test score.

Description of Blueprint Process

- Synthesize key documents to determine prerequisite skills for MSVU intro. stats

Necessary Information	Primary Source
Outcomes for MSVU Intro. Stats course	Internal course outcomes document
Foundational math skills mapping	Mathematics Foundations for Success in Introductory Statistics (Peck, Gould, & Utts, 2019)
Skills that would be reasonably known by many MSVU students	Nova Scotia secondary education curriculum documents (Department of Education and Early Childhood Development, 2019a-g)

- The test blueprint statement will synthesize and summarize the topic that must be assessed on the placement test.
- The test blueprint provides a framework for developing or identifying placement test items, each of which should fit within a blueprint statement.
- *Note*: Existing placement test items are being treated as confidential, so any items shown are recreations similar to such items.

Course Outcomes Document	Bivariate Quantitative Data		
	Scatterplots	**Simple linear regression (descriptive)**	
Requisite Skill as described by (Peck, Gould, & Utts, 2019)	Create scatterplots and residual plots	Calculate residuals	Use the regression line to make predictions
Prerequisite Skill (Peck, Gould, & Utts, 2019)	Plot an ordered pair (x, y) in a rectangular coordinate system	Find the vertical distance between a point and a line	Use the equation of a line to find the y-value associated with a given x-value
Provincial Curriculum Outcomes	Math10: RF04 Students will be expected to describe and represent linear relations, using words, ordered pairs, tables of values, graphs, and equations. RF04.05 Draw a graph from a set of ordered pairs within a given situation, and determine whether the relationship between the variables is linear.	Math 10: RF08 Students will be expected to solve problems that involve the distance between two points and the midpoint of a line segment.	Math 9: PR03 Students will be expected to model and solve problems, where a, b, c, d, e, and f are rational numbers, using linear equations of the form… Math 10:RF06 Students will be expected to relate linear relations to their graphs, expressed in slope-intercept form (y = mx + b), general form (Ax + By + C = 0), slope-point form (y – y1) = m(x – x1)
Blueprint Statement	Students can graph an ordered pair on a scatterplot.	Students can calculate the distance between two points.	Students can use linear equations to calculate unknown values.
Example Item	Item 20: Maddison makes $9.00 per hour selling shirts and earns a $3.00 commission for each shirt she sells. If h represents the number of hours she works, and s represents the number of shirts she sells, and p represents her total pay in dollars, then the relationship among these quantities is correctly represented by [five options given]	Item 16: The line with a slope of -4 and y-intercept 5 passes through the point [five options given] Item 17: a line passing through the point (2,9) and (6,7) has slope [five options given]	Item 10: If $4x - 8y - 3 = -2x - y - 1$, then $y =$ [five options given]

Summary of Results

- Overall, higher placement test scores are associated with a decreased probability of receiving a Low Grade in both introductory statistics and precalculus.
  - ***Next steps:*** Include additional covariates are considered, such as age, gender, ethnicity and accessibility needs.
- Only a few items have very low point biserial correlations.
  - ***Next steps:*** Investigate these items further and explore the psychometric properties of the test and items further.
- The test blueprint shows that some items may be appropriate for a statistics placement test.
  - ***Next steps:*** Identify existing items that fit within the blueprint, explore to what extent an aggregate score from these items is predictive of success, and determine what additional items should be created.

References

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Questions?

Live Q&A on Tuesday,
May 24th at 2:40 – 3:20 PM Eastern

Thank you!

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