Meta-Analysis of Student Achievement on Natural Science FLO SCI1 in a 200-Level Biology Course

Dr. Clifton Franklund[1]

Abstract

This report is a proof-of-concept for the proposed General Education assessment strategy at Ferris State University. Course-level student assessment data was gathered using TracDat and de-identified. The clean and tidy dataset was used to generate this report using the R statistical programming lanuage. Thirteen semesters of student performance on a lecture exam were used to evaluate student competency on Ferris Learning Outcome (FLO) 1. A meta-analysis of these data demonstrated that performance was very near the criterion of success. There was substantial variation in enrollment and course performance over the timespan examined The utility of reports like these to analyze, distribute, and act up General Education assessment data will be investigated using faculty focus groups in the fall of 2016.

Keywords

Meta-Analysis — Forest plot — Natural Sciences — Scientific concepts

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Contents

Assessment is not a spreadsheet;
it's a conversation. — Irmeli Halinen

Introduction

This report is a real analysis of course-level assessment data. However, its primary purpose is to serve as a proof-of-concept for the new General Education assessment process at Ferris State University. Assessment is perhaps best viewed as a scholarly activity that is focused upon programmatic improvement. Such scholarly work should be built upon, and contribute to, the relavent professional literature (Weimer, 2015). To emphasize that reality, this report is formatted in the form of a journal article and will be registered online with a digital objects identifier (doi).

Methods

Collection of assessment data

Student performance on the first lecture exam in a 200-level Biology course was analyzed. The content assessed in all exams was biological diversity. However, the number and format of the questions used varied by semester. Individual student scores were collected using the new General Education Natural Sciences "scores" data workbook for 13 semesters. Student scores were automatically converted to a rubric score by the workbook using the equivalencies shown in Table 1.

Table 1. Conversion of percentages to rubric scores

Percent correct	Rubric	Interpretation
0.0 to 49.9%	0	Unsatisfactory
50.0 to 59.9%	1	Beginning
60.0 to 69.9%	2	Developing
70.0 to 84.9%	3	Proficient
85.0 to 100.0%	4	Advanced

These workbook files contain personally identifiable information (PII) and are, therefore, subject to FERPA regulations. For this reason, they are not directly shared. Instead, they are permanantly housed within a data folder in TracDat: Core Competency: Natural Sciences $\Rightarrow$ Assessment $\Rightarrow$ Proof_of_Concept.
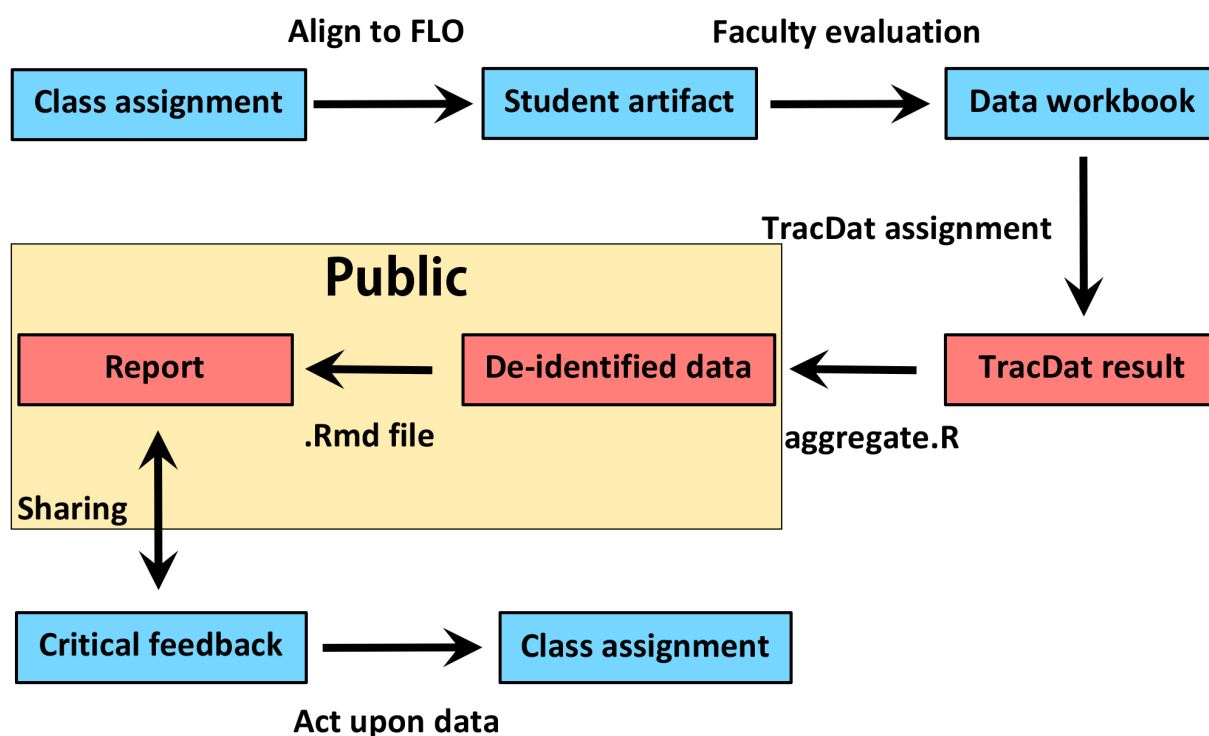
Figure 1. A diagram illustrating the flow of data from initial collection to storage, access, and use. This process constitutes "closing the loop" on assessing General Education competencies. The blue boxes highlight steps with direct faculty involvement; the red boxes indicate processes carried out by the General Education Coordinator. The light yellow region indicates the files that are publicly available on the Open Science Framework.

De-identification of student data

Copies of the 13 data files were downloaded from TracDat. An R aggregator script was used to read the data from these data sheets and contatenate it into one dataset in a destructive process – the downloaded copies were deleted in the process. Student names and identification numbers were redacted and each student's entry was given a unique eight-digit identifier - the Record.Key. These keys may be used for longitudinal studies in the future. The algorithm used is kept in an encrypted site and shared with *no one*. The de-identified dataset contains 973 student entries and is formatted as a comma-delimited textfile (BIOL200Data.csv).

Data provenance

Data provenance is...(Buneman, Khanna, and Wang-Chiew, 2001)

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Citation of this work All of the de-identified data, analysis code, and documentation that constitute this report project may be freely used, modified, and shared. The code file, Gen_Ed_Report_16-01.Rmd, is released under the MIT license. The de-identified dataset, BIOL200Data.csv, is released under the Creative Commons CC0 license. All documentation, including README.md, Codebook.md, and this report, are released under the Creative Commons CC-BY licence. Any questions, comments, or suggestions may be sent to Dr. Franklund.

Session information The following information pertains to the session used to generate this report.

- R version 3.3.0 (2016-05-03),
  `x86_64-apple-darwin13.4.0`

- Base packages: base, datasets, graphics, grDevices, grid, methods, stats, utils
- Other packages: car 2.1-2, dplyr 0.5.0, forestplot 1.5.1, Formula 1.2-1, gdata 2.17.0, ggplot2 2.1.0, Hmisc 3.17-4, knitr 1.13, lattice 0.20-33, magrittr 1.5, mice 2.25, moments 0.14, papeR 1.0-1, Rcpp 0.12.6, survival 2.39-5, weights 0.85, xtable 1.8-2
- Loaded via a namespace (and not attached): acepack 1.3-3.3, assertthat 0.1, chron 2.3-47, cluster 2.0.4, colorspace 1.2-6, data.table 1.9.6, DBI 0.4-1, evaluate 0.9, foreign 0.8-66, formatR 1.4, gmodels 2.16.2, gridExtra 2.2.1, gtable 0.2.0, gtools 3.5.0, latticeExtra 0.6-28, lme4 1.1-12, MASS 7.3-45, Matrix 1.2-6, MatrixModels 0.4-1, mgcv 1.8-13, minqa 1.2.4, munsell 0.4.3, nlme 3.1-128, nloptr 1.0.4, nnet 7.3-12, parallel 3.3.0, pbkrtest 0.4-6, plyr 1.8.4, quantreg 5.26, R6 2.1.2, RColorBrewer 1.1-2, rpart 4.1-10, scales 0.4.0, SparseM 1.7, splines 3.3.0, stringi 1.1.1, stringr 1.0.0, tibble 1.1, tools 3.3.0
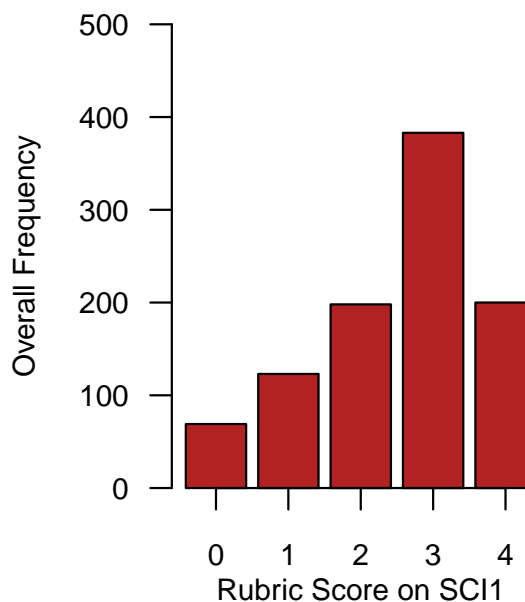
Results

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Structure of the report files

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Summary statistics

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Figure 2. A histogram of the distribution of individual rubric score frequencies over all twelve semesters.

The overall overall average rubric score for all 13 semesters was 2.54. The distribution of the rubrics scores is shown below.

Table 2. One-way ANOVA analysis of scores by semester

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Semester	12	142.74	11.89	9.85	0.0000
Residuals	960	1159.22	1.21		

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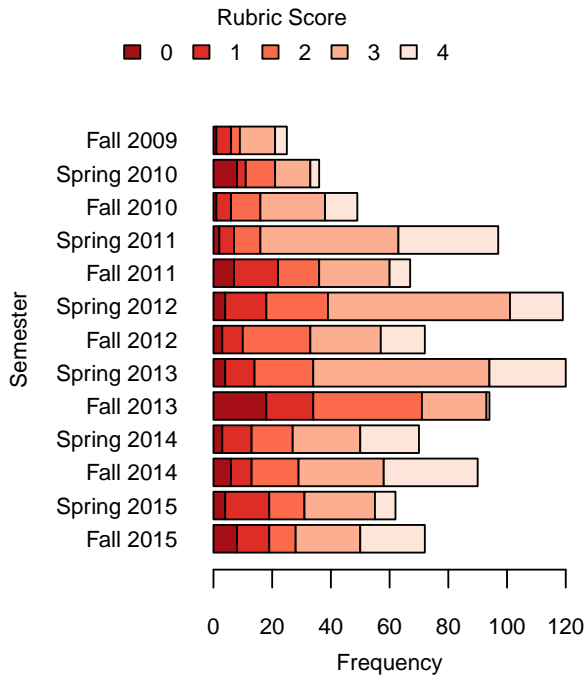
Figure 3. A barplot showing the distribution of rubric scores broken down by semester.

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Meta-analysis

A meta-analysis of the student learning results was performed by examining the weighted average of rubric scores. The fweighted average for semester performance was calculated using formula 1. The confidence interval for the weighted mean was calculated using the calculated variance as described by Cochran (Cochran, 1977). The calculation for weighted variance is shown in formula 2.

$$\bar{X}_w = \frac{\sum X_i W_i}{\sum W_i} \tag{1}$$

$$(SEM_w)^2 = \frac{n}{(n-1)(\sum P_i)^2} \left[\sum (P_i X_i - \bar{P}\bar{X}_w)^2 - 2 \bar{X}_w \sum (P_i - \bar{P})(P_i X_i - \bar{P}\bar{X}_w) + \bar{X}_w^2 \sum (P_i - \bar{P})^2 \right] \tag{2}$$

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Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fri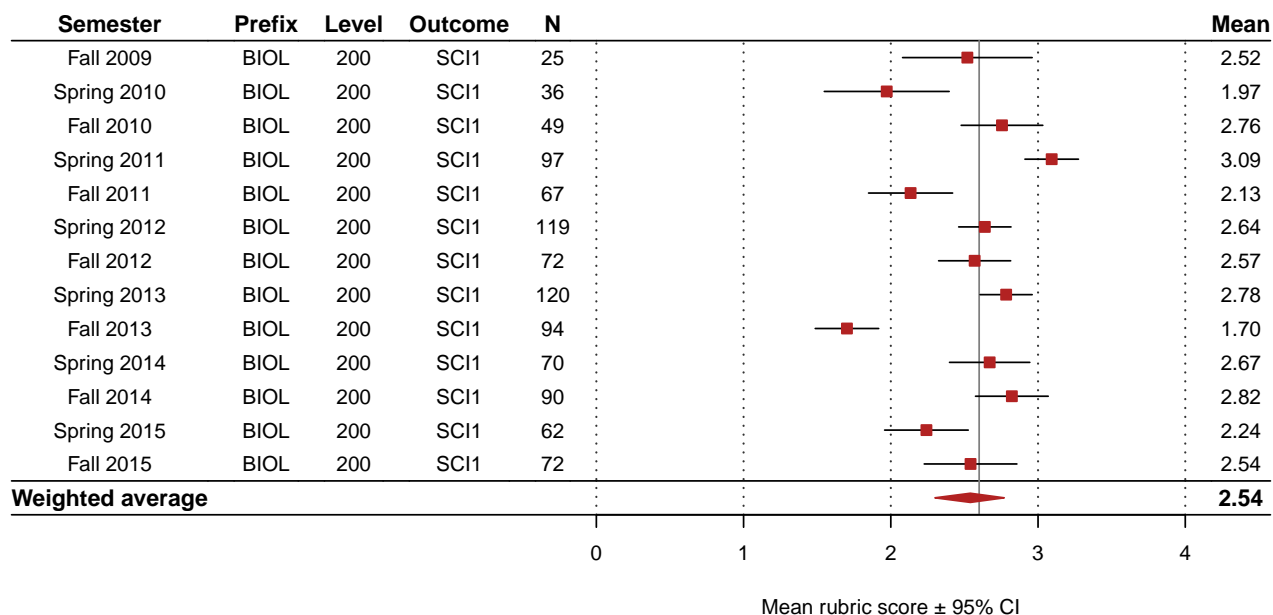ngilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Discussion

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Semester	Prefix	Level	Outcome	N		Mean
Fall 2009	BIOL	200	SCI1	25		2.52
Spring 2010	BIOL	200	SCI1	36		1.97
Fall 2010	BIOL	200	SCI1	49		2.76
Spring 2011	BIOL	200	SCI1	97		3.09
Fall 2011	BIOL	200	SCI1	67		2.13
Spring 2012	BIOL	200	SCI1	119		2.64
Fall 2012	BIOL	200	SCI1	72		2.57
Spring 2013	BIOL	200	SCI1	120		2.78
Fall 2013	BIOL	200	SCI1	94		1.70
Spring 2014	BIOL	200	SCI1	70		2.67
Fall 2014	BIOL	200	SCI1	90		2.82
Spring 2015	BIOL	200	SCI1	62		2.24
Fall 2015	BIOL	200	SCI1	72		2.54
Weighted average						**2.54**

Mean rubric score ± 95% CI

Figure 4. A forest plot of the average scores for each semester with a weighted mean estimate for the entire period investigated. Error bars indicate the 95% confidence intervals.

Table 3. Table of Grades

Name		
First name	Last Name	Grade
John	Doe	7.5
Richard	Miles	2

Faculty feedback

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Word Definition
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- No modifications

- Modify the assignment
- Modify instruction
- Modify the learning outcome
- Modify the competency

Acknowledgments

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