Supplemental Material

CBE—Life Sciences Education

Goodwin *et al.*

Is this Science? Exploring Student Beliefs about what Makes a Research-Based Course Feel Authentic

Supplemental Materials

Goodwin *et. al* 2020

Table of Contents

Appendix 1. Laboratory Course Assessment Survey (LCAS)

Adapted from Corwin et al., 2015:

Construct	Prompt	Item #	Item Text	Item Response Options
Collaboration	I was encouraged to…	C1	discuss elements of my investigation with classmates or instructors	1[#]: Never 2: Only once 3: A couple of times, but not every lab period 4: About once per lab period 5: Multiple times during most lab periods
		C2	reflect on what I was learning	
		C3	contribute my ideas and suggestions during class discussions	
		C4	help other students collect or analyze data	
		C5	provide constructive criticism to classmates and challenge each other's interpretations	
		C6	share the problems I encountered during my investigation and seek input on how to address them	
Discovery/Relevance	I was expected to…	D1	generate novel results that are unknown to the instructor and that could be of interest to the broader scientific community or others outside of class	1: Strongly disagree 2: Disagree 3: Somewhat disagree 4: Somewhat agree 5: Agree 6: Strongly agree
		D2	conduct an investigation to find something previously unknown to myself, other students, and the instructor	
		D3*	formulate my own research questions or hypothesis to guide an investigation	
		D4	develop new arguments based on data	
		D5	explain how my work has resulted in new scientific knowledge	
		I1*	revise or repeat work to account for errors or fix problems	
Iteration	I had time to…	I2	change the methods of the investigation if it was not unfolding as predicted	
		I3	share and compare data with other students	
		I4	collect and analyze additional data to address new questions or further test hypotheses that arose during the investigation	
		I5	revise or repeat analyses based on feedback	
		I6	revise drafts of papers or presentations about my investigation based on feedback	

*Indicates items D3 and I1, which were removed from analyses due to content and structural validity issues (respectively). I1 is included with the Discovery/Relevance *items in this table due to the common question stem ("I was expected to…."). [#]Note that original item response options for the* Collaboration *scale are as follows: 1= Weekly; 2= Monthly; 3= One or two times, 4= Never. We have reversed the item coding for this scale to follow the same direction as the Iteration and Discovery/Relevance scales.*

Appendix 2. LCAS Correlated Three-Factor Model

Adapted from Corwin et al., 2015:
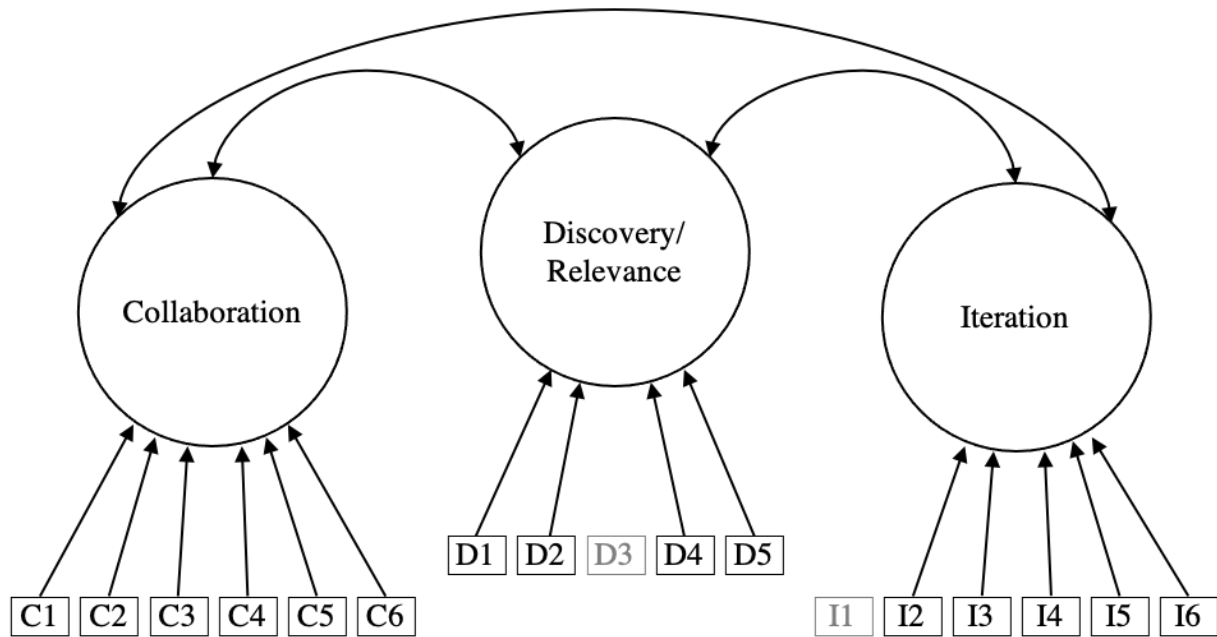
We used the Laboratory Course Assessment Survey to test a correlated three-factor model of *Collaboration, Relevant Discovery,* and *Iteration*. Boxes with item numbers represent the survey items that serve as indicators for each latent factor. Two items (D3 and I1, in grey) were not included in our final model.

Appendix 3. Participant demographics and chi-square tests of independence

Demographics[a]	Inquiry Students n = 302	CURE Students n = 74	χ^2 Test Results
	n (%)	n (%)	
Legal Sex[b]			
Female	179 (59.3)	47 (63.5)	
Male	120 (39.7)	27 (36.5)	$\chi^2 = 0.33, p = 0.565$
Race/Ethnicity[c]			
Underrepresented Minority (URM)	62 (20.5)	12 (16.2)	
Non-URM	240 (79.5)	62 (83.8)	$\chi^2 = 0.69, p = 0.403$
Generation Status			
First Generation	103 (34.1)	22 (29.7)	
Continuing Generation	147 (48.7)	36 (48.6)	$\chi^2 = 0.21, p = 0.648$
Transfer Status			
Transfer Undergraduate	110 (36.4)	30 (40.5)	
Non- Transfer Undergraduate	156 (51.7)	30 (40.5)	$\chi^2 = 1.49, p = 0.222$
Post-Baccalaureate			
Post-Bac	35 (11.6)	14 (18.9)	
Undergraduate	267 (88.4)	60 (81.1)	$\chi^2 = 2.81, p = 0.093$
Major			
Biology	162 (53.6)	43 (58.1)	
Other STEM Major	130 (43.0)	29 (39.2)	$\chi^2 < 0.42, p = 0.516$

[a] Unless otherwise stated, data was obtained from the institutional database. Percentages in each demographic group may not add up to 100% due to missing student information for certain demographic categories. [b] We were unfortunately only able to obtain legal sex information from our institution, which likely mischaracterizes the gender identity of some of our participants. [c] Students who identified as Hispanic/Latino, Native American/Alaskan/Hawaiian, Black or African American, and Pacific Islander were classified as underrepresented minorities (URM).

Appendix 4. LCAS Item Summary Statistics

Summary statistics for items in each of the three LCAS constructs are included in the tables below. Suggested interpretations of skewness and kurtosis when evaluating normality of data vary widely. Overall, our items show little skew (all absolute skewness values are less than 2.0), and some kurtosis (ranging between 1.6 and 5.5). Acceptable absolute kurtosis values for normal data range from below 2.0 ("conservative", Hancock et al., 2018) to below 7.0 ("liberal", Hancock et al., 2018) or even below 10.0 ("conservative"; Kline, 2015). To account for this moderate non-normality of our data, we used a robust estimator in our confirmatory factor analyses.

Collaboration Item Summary Statistics

Items	Group	Mean	SD	Median	Min	Max	Skewness	Kurtosis
	CURE	4.65	0.61	5	3	5	-1.54	4.22
C1	Inquiry	4.28	0.94	5	1	5	-1.25	4.11
	Total	4.34	0.90	5	1	5	-1.36	4.47
	CURE	4.60	0.58	5	3	5	-1.14	3.31
C2	Inquiry	4.15	0.95	4	1	5	-1.12	4.16
	Total	4.23	0.91	4	1	5	-1.23	4.54
	CURE	4.35	0.90	5	2	5	-1.14	3.22
C3	Inquiry	3.95	1.13	4	1	5	-1.05	3.51
	Total	4.02	1.10	4	1	5	-1.10	3.64
	CURE	4.33	0.99	5	1	5	-1.57	4.97
C4	Inquiry	4.33	0.91	5	1	5	-1.40	4.93
	Total	4.33	0.92	5	1	5	-1.44	4.96
	CURE	4.02	1.06	4	1	5	-1.02	3.81
C5	Inquiry	3.56	1.25	4	1	5	-0.56	2.44
	Total	3.65	1.23	4	1	5	-0.64	2.59
	CURE	4.42	0.79	5	2	5	-1.17	3.54
C6	Inquiry	4.03	1.09	4	1	5	-1.05	3.58
	Total	4.10	1.05	4	1	5	-1.13	3.80

Discovery Item Summary Statistics

Items	Group	Mean	SD	Median	Min	Max	Skewness	Kurtosis
D1	CURE	5.14	0.80	5	4	6	-0.25	1.62
	Inquiry	4.23	1.31	4	1	6	-0.47	2.62
	Total	4.39	1.28	4	1	6	-0.60	2.81
D2	CURE	5.40	0.69	6	4	6	-0.70	2.33
	Inquiry	4.67	1.15	5	1	6	-0.93	3.79
	Total	4.80	1.12	5	1	6	-1.03	4.08
D4	CURE	5.19	0.76	5	4	6	-0.32	1.81
	Inquiry	4.83	0.98	5	1	6	-0.91	4.27
	Total	4.89	0.96	5	1	6	-0.91	4.31
D5	CURE	5.28	0.67	5	4	6	-0.37	2.24
	Inquiry	4.63	1.15	5	1	6	-0.89	3.86
	Total	4.74	1.10	5	1	6	-1.00	4.21

Iteration Item Summary Statistics

Items	Group	Mean	SD	Median	Min	Max	Skewness	Kurtosis
I1	CURE	5.40	0.73	6	3	6	-1.13	4.13
	Inquiry	4.50	1.28	5	1	6	-0.87	3.37
	Total	4.66	1.25	5	1	6	-1.00	3.69
I2	CURE	5.23	0.84	5	3	6	-0.70	2.46
	Inquiry	4.31	1.34	4	1	6	-0.71	2.95
	Total	4.48	1.31	5	1	6	-0.82	3.19
I3	CURE	5.37	0.69	5	4	6	-0.63	2.28
	Inquiry	4.99	1.01	5	1	6	-1.32	5.45
	Total	5.06	0.97	5	1	6	-1.36	5.71
I4	CURE	5.28	0.80	5	3	6	-0.82	2.94
	Inquiry	4.54	1.30	5	1	6	-0.93	3.27
	Total	4.68	1.26	5	1	6	-1.04	3.61
I5	CURE	5.26	0.69	5	4	6	-0.38	2.13
	Inquiry	4.24	1.36	4	1	6	-0.60	2.55
	Total	4.42	1.33	5	1	6	-0.77	2.87
I6	CURE	5.44	0.67	6	4	6	-0.77	2.50
	Inquiry	4.04	1.47	4	1	6	-0.37	2.15
	Total	4.29	1.46	5	1	6	-0.58	2.35

Appendix 5. Reliability estimates for LCAS scales

McDonald's Omega was used to estimate reliability for all three subscales of the Laboratory Course Assessment Survey (Komperda et al., 2018). In general, reliability coefficients above 0.8 are "very good", indicating that all three subscales have acceptable internal consistency for these analyses (Kline, 2015). McDonald's Omega total for *Collaboration, Iteration*, and *Discovery/Relevance* was 0.86, 0.89, and 0.90 respectively.

References

Corwin, L. A., Runyon, C., Robinson, A., & Dolan, E. L. (2015). The laboratory course assessment survey: A tool to measure three dimensions of research-course design. *CBE— Life Sciences Education*, *14*(4), ar37.

Hancock, G. R., Stapleton, L. M., Mueller, R. O., Stapleton, L. M., & Mueller, R. O. (2018). *The Reviewer's Guide to Quantitative Methods in the Social Sciences*. Routledge. https://doi.org/10.4324/9781315755649

Kline, R. B. (2015). *Principles and Practice of Structural Equation Modeling, Fourth Edition*. Guilford Publications.

Komperda, R., Pentecost, T. C., & Barbera, J. (2018). Moving beyond Alpha: A Primer on Alternative Sources of Single-Administration Reliability Evidence for Quantitative Chemistry Education Research. *Journal of Chemical Education*, *95*(9), 1477–1491. https://doi.org/10.1021/acs.jchemed.8b00220