

Supplemental Material

CBE—Life Sciences Education

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GenBio-MAPS as a case study to understand and address the effects of test-taking motivation in low-stakes program assessments

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Supplemental Table 1. Institution and course demographics^a		
Institution characteristic	n	%
Control		
Public	15	75
Private	5	25
Region ^b		
Mid-Atlantic	2	10
Midwest	10	50
Northwest	3	15
Southwest	5	25
Carnegie basic classification		
Associate's Colleges: Mixed Transfer/Career & Technical-High Nontraditional	2	10
Baccalaureate Colleges: Arts & Sciences Focus	3	15
Master's Colleges & Universities: Larger or Medium Programs	7	35
Doctoral Universities: Higher or Moderate Research Activity	3	15
Doctoral Universities: Highest Research Activity	5	25
Course time point		
Beginning of introductory series	58	38
End of introductory series	45	30
Advanced	49	32
^a Data originally collected and reported in Couch <i>et al.</i> (2019).		
^b Region designations are based on PULSE regional boundaries. No institutions from the Northeast or Southeast regions are represented in the data set.		

Supplemental Table 2. Number of page times replaced^a	
Number of pages replaced	Percent of students
0	88.4
1 - 5	11.5
6 - 10	0.1
10 -15	0

^a Students saw one multiple-true-false question containing 4-5 T/F statements per page. Response times to individual questions exceeding 15 minutes were replaced with the average page time of 1.5 minutes

Supplemental Table 3. Response time thresholds for GenBio-MAPS questions^a		
GenBio-MAPS question	Number of characters in question	Response threshold
BM-01	855	8.55
BM-02	633	6.33
BM-03	875	8.75
BM-04	758	7.58
BM-07	717	7.17
BM-08	1299	12.99
BM-12	1036	10.36
BM-13	937	9.37
BM-14	418	4.18
BM-15	1163	11.63
BM-16	895	8.95
BM-18	762	7.62
BM-19	700	7.00
BM-20	954	9.54
BM-21	1172	11.72
BM-22	1083	10.83
BM-23	462	4.62
BM-24	825	8.25
BM-27	920	9.20
BM-28	973	9.73
BM-30	904	9.04
BM-31	466	4.66
BM-32	840	8.40
BM-33	912	9.12
BM-35	970	9.70
BM-36	777	7.77
BM-37	988	9.88
BM-38	866	8.66
BM-40	749	7.49
BM-43	726	7.26
BM-44	858	8.58
BM-45	737	7.37
BM-49	618	6.18
BM-50	938	9.38
BM-54	1069	10.69
BM-55	1480	14.80
BM-59	1344	13.44
BM-60	1188	11.88
BM-61	733	7.33

^a Response time thresholds were calculated based on a rate of 100 characters per second.

Supplemental Table 4. Correlations between demographic variables, test-taking effort, and GenBio-MAPS score

	Gender	Race/Ethnicity	Parental education	Language	Major	Self-reported effort	Test completion time	Solution behavior	GenBio-MAPS score
Gender	–	-0.01	-0.02	-0.02	0.01	-0.00	0.03**	0.04***	-0.12***
Race/ethnicity	-0.01	–	0.19***	0.14***	-0.04***	0.04***	-0.04***	0.03**	0.14***
Parental education	-0.02	0.19***	–	0.17***	-0.02	-0.00	-0.01	0.04***	0.18***
Language	-0.02	0.14***	0.17***	–	-0.02*	0.06***	-0.02*	0.05***	0.09***
Major	0.01	-0.04***	-0.02	-0.02*	–	0.05***	0.07***	0.07***	0.12***
Self-reported effort	-0.00	0.04***	-0.00	0.06***	0.05***	–	0.23***	0.33***	0.29***
Test completion time	0.03**	-0.04***	-0.01	-0.02*	0.07***	0.23***	–	0.51***	0.30***
Solution behavior	0.04***	0.03**	0.04***	0.05***	0.07***	0.33***	0.51***	–	0.42***
GenBio-MAPS score	-0.12***	0.14***	0.18***	0.09***	0.12***	0.29***	0.30***	0.42***	–

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Supplemental Table 5. Standard least squares linear regression model^a of the effects of student demographic characteristics on self-reported effort

Parameter^b	Estimate	SE	df	t	p
Intercept	3.203	0.033	23.69	96.95	<0.0001
Gender: male (ref: female)	0.003	0.009	7536	0.37	0.7086 ^c
Race/ethnicity: underserved (ref: non-underserved)	-0.031	0.011	7366	-2.92	0.0035
Parental education: did not complete bachelor's degree (ref: completed bachelor's degree)	0.020	0.009	7483	2.22	0.0263
Language: English not spoken at home (ref: English spoken at home)	-0.064	0.012	7534	-5.18	<0.0001
Major: not majoring in biology (ref: majoring in biology)	-0.046	0.009	7518	-4.81	<0.0001

^a Self-reported effort ~ institution + gender + race/ethnicity + parental education + language + major + time point. Only variables that passed model selection are listed.

^b Estimates for nominal variables indicate the effect based on being a member of the focal group in comparison to the reference (ref) group.

^c Removing this non-significant term raised AIC above the threshold for exclusion.

Supplemental Table 6. Standard least squares linear regression models^a of the effects of student demographic characteristics and self-reported effort on observed test-taking behaviors

Parameter ^b	Solution behavior					Test completion time (minutes)				
	Estimate	SE	df	t	p	Estimate	SE	df	t	p
Intercept	0.612	0.013	133.3	47.69	<.0001	13.86	0.977	120.1	14.18	<.0001
Gender: male (ref: female)	-0.011	0.002	7656	-4.89	<.0001	-0.568	0.174	7531	-3.26	0.0011
Race/ethnicity: underserved (ref: non-underserved)						1.081	0.217	7146	4.98	<.0001
Parental education: did not complete bachelor's degree (ref: completed bachelor's degree)	-0.008	0.002	7550	-3.30	0.0010	-0.029	0.182	7406	-0.16	0.8746 ^c
Language: English not spoken at home (ref: English spoken at home)	-0.009	0.003	7636	-2.64	0.0084	0.551	0.253	7502	2.18	0.0294
Major: not majoring in biology (ref: majoring in biology)	-0.009	0.003	7608	-3.68	0.0002	-0.905	0.196	7428	-4.61	<.0001
Time point: end of introductory series (ref: beginning of introductory series)	-0.016	0.005	5818	-3.09	0.0020	-2.741	0.400	4854	-6.86	<.0001
Time point: advanced series (ref: end of introductory series)	0.040	0.007	7426	5.65	<.0001	4.147	0.552	7093	7.51	<.0001
Self-reported effort	0.087	0.003	7666	28.81	<.0001	4.564	0.234	7542	19.47	<.0001

^a Solution behavior ~ institution + gender + race/ethnicity + parental education + language + major + time point + self-reported effort; Test completion time ~ institution + gender + race/ethnicity + parental education + language + major + time point + self-reported effort. Only variables that passed model selection are listed.

^b Estimates for nominal variables indicate the effect based on being a member of the focal group in comparison to the reference (ref) group.

^c Removing this non-significant term raised AIC above the threshold for exclusion.

Supplemental Table 7. Standard least squares linear regression model of the effects of student demographic characteristics and test-taking effort on GenBio-MAPS score

Parameter	Self-reported effort					Solution behavior					Test completion time (minutes)				
	Estimate	SE	df	t	p	Estimate	SE	df	t	p	Estimate	SE	df	t	p
Intercept	0.459	0.011	65.49	40.78	<.0001	0.415	0.010	81.39	39.61	<.0001	0.530	0.009	27.05	60.69	<.0001
Gender: male (ref: female)	0.013	0.001	7525	10.73	<.0001	0.016	0.001	7664	14.09	<.0001	0.014	0.001	7663	12.20	<.0001
Race/ethnicity: underserved (ref: non-underserved)	-0.011	0.001	7542	-7.36	<.0001	-0.012	0.001	7679	-8.32	<.0001	-0.014	0.001	7680	-9.88	<.0001
Parental education: did not complete bachelor's degree (ref: parent completed bachelor's degree)	-0.013	0.001	7541	-10.79	<.0001	-0.012	0.001	7680	-9.99	<.0001	-0.013	0.001	7680	-10.51	<.0001
Language: English not spoken at home (ref: English spoken at home)	-0.014	0.002	7536	-8.23	<.0001	-0.014	0.002	7676	-8.55	<.0001	-0.017	0.002	7675	-10.06	<.0001
Major: not majoring in biology (ref: majoring in biology)	-0.009	0.001	7540	-6.54	<.0001	-0.007	0.001	7679	-5.92	<.0001	-0.008	0.001	7678	-5.89	<.0001
Time point [2-1]: end of introductory series (ref: beginning of introductory series)	0.054	0.003	7444	19.39	<.0001	0.057	0.003	7551	22.15	<.0001	0.061	0.003	7576	22.32	<.0001
Time point [3-2]: advanced series (ref: end of introductory series)	0.064	0.004	7542	16.88	<.0001	0.052	0.004	7679	14.37	<.0001	0.055	0.004	7680	14.53	<.0001
Self-reported effort	0.038	0.002	7530	16.39	<.0001	.	.	.	.	.	.	.	.	.	.
Time point [2-1]*self-reported effort	0.009	0.004	7532	2.60	0.0093	.	.	.	.	.	.	.	.	.	.
Time point [3-2]*self-reported effort	0.022	0.005	7527	4.48	<.0001	.	.	.	.	.	.	.	.	.	.
Solution behavior	.	.	.	.	.	0.185	0.008	7670	22.71	<.0001	.	.	.	.	.
Time point [2-1]*solution behavior	.	.	.	.	.	0.067	0.011	7672	6.02	<.0001	.	.	.	.	.
Time point [3-2]*solution behavior	.	.	.	.	.	0.112	0.019	7665	5.83	<.0001	.	.	.	.	.
Test completion time	.	.	.	.	.	.	.	.	.	.	0.002	0.000	7675	16.14	<.0001
Time point [2-1]*test completion time	.	.	.	.	.	.	.	.	.	.	0.001	0.000	7672	7.48	<.0001
Time point [3-2]*test completion time	.	.	.	.	.	.	.	.	.	.	-0.000	0.000	7665	-1.54	0.1228

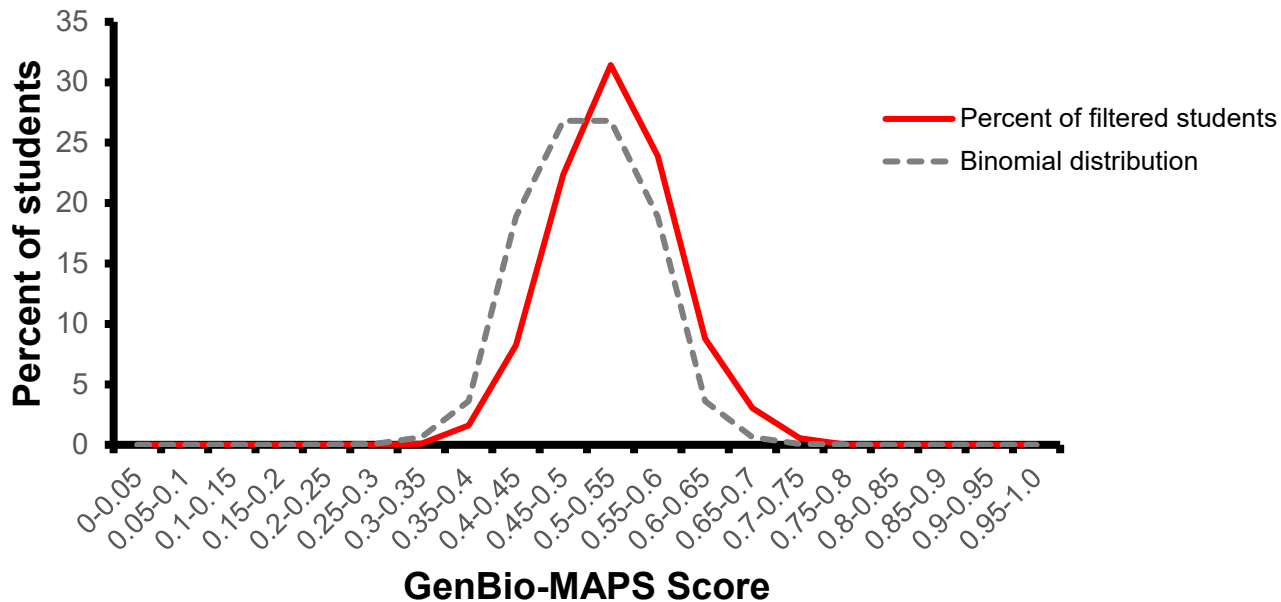
. Parameter not included in the model

Supplemental Table 8. Standard least squares linear regression models^a on the effects of question display order on persistence behaviors and question score

Model outcome variable	Question display order estimate^b	<i>p</i>	R²
Question solution behavior	-0.0109	<0.0001	0.5072
Question time (minutes)	-0.0588	<0.0001	0.3676
Question score	-0.0034	<0.0001	0.3069

^a Question solution behavior ~ student + GenBio-MAPS question + display order; Question time ~ student + GenBio-MAPS question + display order; Question score ~ student + GenBio-MAPS question + display order

^b The estimate represents the change in the proportion of students using solution behavior on a question, the amount of time per question, or the proportion of correct responses as a student moves to each subsequent question.



SUPPLEMENTAL FIGURE 1. Distribution of GenBio-MAPS scores from students who were removed by our dual motivation filter compared to a binomial distribution arising from random responses. The red line represents the scores of students removed by the dual motivation filter who had demonstrated unmotivated behavior through low solution behavior or short test completion time. The gray dotted line represents a binomial distribution based on a 50% chance of correctly responding to 67 T/F statements, which represents the average number of statements seen by filtered students.