

Supplemental Material

CBE—Life Sciences Education

Cole and Beck

Table S1: Demographics of the sample

Female/male	First-generation	PEER	Race/ethnicity	Count
Female	Yes	Yes	African American	13
			Hispanic	9
			Multi-racial	6
		No	Asian	14
			Caucasian	7
			Missing	1
	No	Yes	African American	8
			Hispanic	9
			Multi-racial	11
		No	Asian	68
			Caucasian	63
			Multi-racial	4
	Missing	Missing	1	
	Missing	Yes	African American	1
			Hispanic	1
No		Asian	4	
		Caucasian	3	
Male	Yes	Yes	African American	1
			Hispanic	6
			Multi-racial	1
		No	Asian	11
			Caucasian	3
	No	Yes	African American	3

			Hispanic	3
			Multi-racial	9
		No	Asian	42
			Caucasian	26
			Multi-racial	3
	Missing	Missing	2	
	Missing	Yes	Hispanic	1
		No	Asian	6
			Caucasian	1
		Missing	Missing	1
Missing	Yes	Missing	Missing	1
	No	Yes	African American	1
		No	Caucasian	2
		Missing	Missing	2
	Missing	No	Multi-racial	1
		Missing	Missing	1

Table S2: Comparison of student affect measures for students who completed all three surveys compared to those that did not complete survey at the end of the second semester of introductory biology

	Self-efficacy			Science identity			Scientific community values		
	Mean	Standard Deviation	Effect Size	Mean	Standard Deviation	Effect Size	Mean	Standard Deviation	Effect Size
Beginning of first semester									
Completed end of second-semester survey	3.76	0.67	0.25	3.66	0.71	0.58	5.22	0.69	0.47
Did not complete end of second-semester survey	3.59	0.71		3.21	0.83		4.83	0.95	
End of first semester									
Completed end of second-semester survey	4.31	0.69	0.38	3.96	0.78	0.58	5.29	0.73	0.53
Did not complete end of second-semester survey	4.03	0.79		3.45	0.96		4.83	1.00	

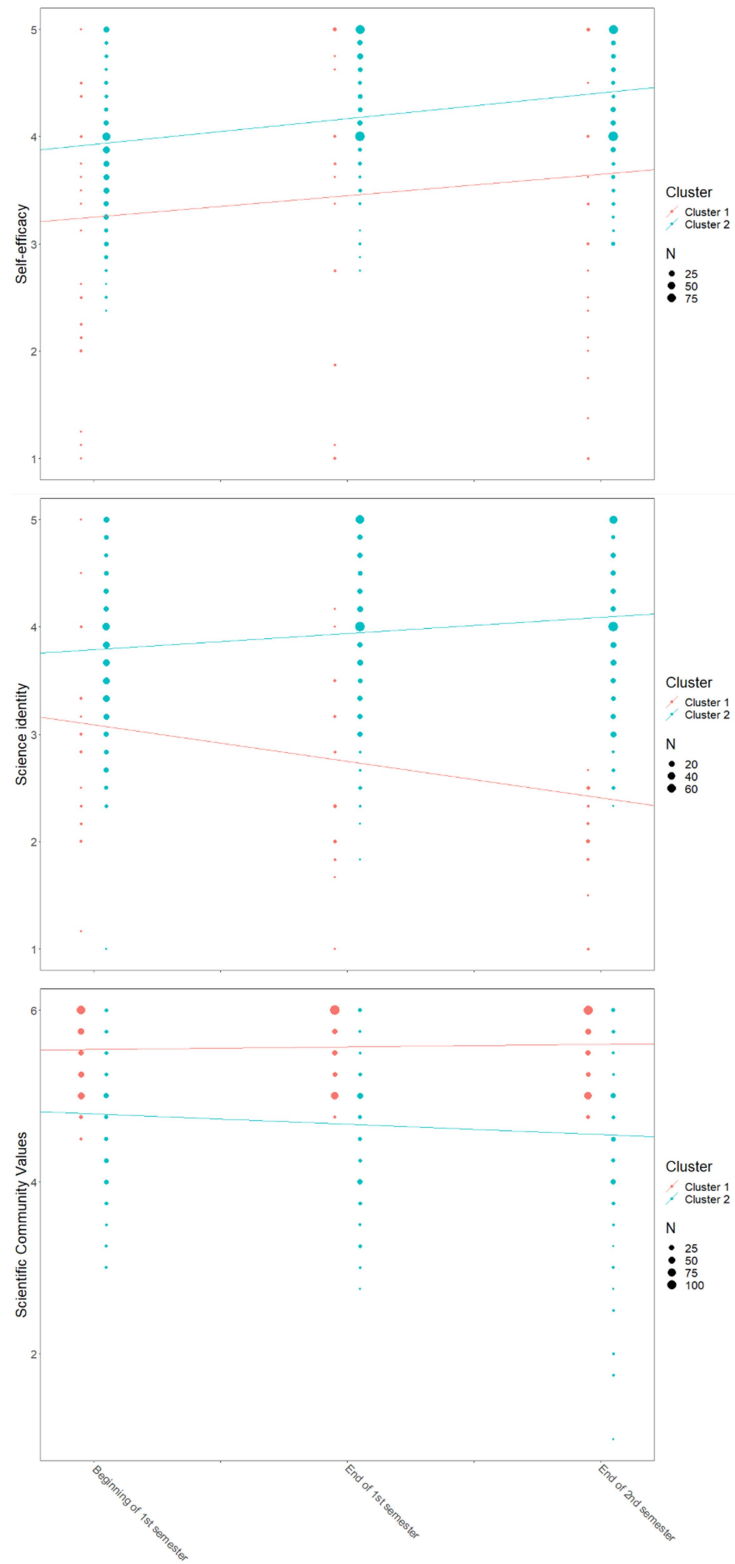


Figure S1. Developmental trajectories for self-efficacy, science identity, and scientific community values based on growth mixture models

Table S3: Student self-efficacy at the beginning, middle, and end of a two-semester introductory biology sequence for different demographic groups.

Cluster 1							
		Beginning Semester 1		End Semester 1		End Semester 2	
	N	Mean	St Dev	Mean	St Dev	Mean	St Dev
Female	19	2.63	1.07	3.89	1.40	3.49	1.26
Male	5	3.98	0.96	2.17	1.63	3.50	1.26
Missing	2	3.00	1.41	2.75	0.00	1.50	0.71
not PEERS	18	3.03	1.21	3.73	1.48	3.47	1.40
PEERS	6	2.56	1.03	2.94	1.89	3.56	0.50
Missing	2	3.00	1.41	2.75	0.00	1.50	0.71
not first-generation	18	2.77	1.14	3.51	1.54	3.39	1.41
first-generation	5	3.48	1.36	3.12	1.94	3.35	1.34
Missing	3	2.88	0.99	3.79	1.13	3.00	0.88
Cluster 2							
		Beginning Semester 1		End Semester 1		End Semester 2	
	N	Mean	St Dev	Mean	St Dev	Mean	St Dev
Female	204	3.76	0.55	4.37	0.51	4.27	0.53
Male	113	3.94	0.59	4.42	0.49	4.37	0.55
Missing	5	3.75	0.32	3.82	0.65	4.15	0.42
not PEERS	239	3.87	0.58	4.42	0.52	4.35	0.55
PEERS	77	3.69	0.50	4.26	0.46	4.20	0.50
Missing	6	3.81	0.63	4.35	0.46	4.19	0.42
not first-generation	239	3.85	0.57	4.39	0.51	4.34	0.55
first-generation	66	3.73	0.55	4.39	0.49	4.24	0.51

Missing	17	3.83	0.54	4.21	0.62	4.09	0.49
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Table S4: Student science identity at the beginning, middle, and end of a two-semester introductory biology sequence for different demographic groups.

Cluster 1							
		Beginning Semester 1		End Semester 1		End Semester 2	
	N	Mean	St Dev	Mean	St Dev	Mean	St Dev
Female	14	2.69	0.47	2.54	0.62	2.02	0.43
Male	6	3.31	1.47	2.94	1.26	2.25	0.23
Missing	3	3.11	1.02	2.11	0.19	1.67	0.58
not PEERS	16	2.93	0.96	2.75	0.86	2.12	0.43
PEERS	4	2.67	0.61	2.29	0.82	1.96	0.16
Missing	3	3.11	1.02	2.11	0.19	1.67	0.58
not first-generation	17	2.94	0.99	2.62	0.88	2.01	0.47
first-generation	4	2.83	0.58	2.67	0.78	2.00	0.14
Missing	2	2.75	0.83	2.17	0.24	2.33	0.47
Cluster 2							
		Beginning Semester 1		End Semester 1		End Semester 2	
	N	Mean	St Dev	Mean	St Dev	Mean	St Dev
Female	209	3.66	0.70	4.03	0.67	3.97	0.65
Male	113	3.85	0.59	4.14	0.67	4.10	0.68
Missing	5	3.33	0.46	3.20	0.18	3.47	0.36
not PEERS	242	3.74	0.69	4.10	0.69	4.07	0.68
PEERS	79	3.65	0.60	3.92	0.62	3.84	0.58
Missing	6	3.78	0.80	3.97	0.53	4.00	0.56
not first-generation	240	3.73	0.70	4.06	0.69	4.03	0.68
first-generation	69	3.67	0.61	4.05	0.62	3.93	0.63

Missing	18	3.79	0.46	4.07	0.74	4.10	0.49
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Table S5: Student science community values at the beginning, middle, and end of a two-semester introductory biology sequence for different demographic groups. The data are presented for two separate clusters that show different science community values across time based on a growth mixture model.

Cluster 1							
		Beginning Semester 1		End Semester 1		End Semester 2	
	N	Mean	St Dev	Mean	St Dev	Mean	St Dev
Female	154	5.51	0.45	5.61	0.44	5.55	0.45
Male	75	5.54	0.44	5.66	0.41	5.59	0.43
Missing	1	5.50	NA	4.75	NA	5.75	NA
not PEERS	171	5.53	0.44	5.65	0.42	5.59	0.45
PEERS	55	5.48	0.47	5.55	0.46	5.47	0.42
Missing	4	5.62	0.48	5.50	0.58	5.81	0.24
not first-generation	180	5.54	0.44	5.61	0.44	5.58	0.44
first-generation	42	5.43	0.45	5.68	0.40	5.51	0.45
Missing	8	5.41	0.48	5.56	0.44	5.56	0.48
Cluster 2							
		Beginning Semester 1		End Semester 1		End Semester 2	
	N	Mean	St Dev	Mean	St Dev	Mean	St Dev
Female	67	4.69	0.66	4.57	0.72	4.37	0.73
Male	44	4.57	0.83	4.77	0.76	4.51	1.08
Missing	7	4.68	0.88	4.21	0.76	4.04	1.86
not PEERS	85	4.58	0.77	4.65	0.75	4.45	0.93
PEERS	28	4.87	0.60	4.69	0.69	4.44	0.79
Missing	5	4.50	0.85	3.95	0.82	3.40	1.85
not first-generation	75	4.65	0.78	4.56	0.79	4.36	1.09

first-generation	31	4.69	0.58	4.73	0.65	4.54	0.53
Missing	12	4.50	0.90	4.81	0.73	4.31	1.01

Table S6: Cronbach's alpha values for each measure of student affect at each time point

Measure	Beginning of first semester	End of first semester	End of second semester
Self-efficacy	0.90	0.96	0.93
Science identity	0.86	0.91	0.90
Scientific community values	0.86	0.89	0.86

Table S7. Confirmatory factor analysis measures for survey at each time point

Fit measure	Beginning of first semester	End of first semester	End of second semester
RMSEA	0.068	0.083	0.073
SRMR	0.052	0.047	0.039
CFI	0.935	0.942	0.957

Table S8: Model fit statistics for growth mixture model (GMM) for self-efficacy. Each GMM was fitted with one to nine classes. Only models for which a solution was possible are reported. The best model based on SABIC is highlighted in bold.

Model	Random effects	Random effects variance	Residual variance	Number of classes	Log-likelihood	AIC	BIC	SABIC	ICL	EIC
Model 1	null				-1137.677	2279.355	2287.058405	2292.418164	2289.256	
Model 2	intercept	fixed	fixed	1	-1057.426	2122.853	2138.26081	2148.980327	2142.656	
				2	-1057.42	2128.84	2155.805417	2174.564573	2621.612	0.001476
Model 3	intercept, slope	fixed	fixed	1	-1057.487	2126.973	2150.087215	2166.166491	2156.678	
				2	-1057.487	2132.973	2167.643822	2191.762736	2603.533	0.005777
Model 4	intercept	class-specific	fixed	1	-1057.426	2122.853	2138.26081	2148.980327	2142.656	
				2	-1037.681	2091.363	2122.17962	2143.618654	2132.721	0.988683
				3	-1029.796	2083.593	2129.81843	2161.976982	2145.165	0.992854
				4	-1029.773	2091.546	2153.18124	2196.059309	2551.936	0.518026
				5	-1029.781	2099.562	2176.60605	2230.203636	2800.805	0.340602
Model 5	intercept, slope	class-specific	fixed	1	-1057.487	2126.973	2150.087215	2166.166491	2156.678	
				2	-1025.71	2075.42	2121.64643	2153.804982	2150.351	0.888272
Model 6	intercept	fixed	class-specific	1	-1057.4264	2122.853	2138.26161	2148.981127	2142.656	
				2	-955.3488	1926.698	1957.51522	1978.954254	1997.172	0.812217
Model 7	intercept,	fixed	class-	1	-1057.4867	2126.973	2150.086615	2166.165891	2156.678	

	slope		specific							
				2	-955.6992	1931.398	1969.920425	1996.719218	2011.201	0.815105
Model 8	intercept	class-specific	class-specific	1	-1057.4264	2122.853	2138.26161	2148.981127	2142.656	
				2	-953.9723	1925.945	1960.614422	1984.733336	2002.546	0.809836
Model 9	intercept, slope	class-specific	class-specific	1	-1057.4867	2126.973	2150.086615	2166.165891	2156.678	
				2	-954.1604	1934.321	1984.399432	2019.237863	2030.637	0.811238

Table S8: Model fit statistics for growth mixture model (GMM) for science identity. Each GMM was fitted with one to nine classes. Only models for which a solution was possible are reported. The best model based on SABIC is highlighted in bold.

Model	Random effects	Random effects variance	Residual variance	Number of classes	Log-likelihood	AIC	BIC	SABIC	ICL	EIC
Model 1	null				-1225.183	2454.367	2462.081866	2469.650246	2464.28	
Model 2	intercept	fixed	fixed	1	-1071.274	2150.548	2165.979733	2181.116491	2170.374	
				2	-1053.034	2120.068	2147.073532	2173.56286	2190.085	0.835038
				3	-1052.966	2125.931	2164.511332	2202.353228	2515.515	0.356328
Model 3	intercept, slope	fixed	fixed	1	-1065.472	2142.944	2166.091599	2188.796737	2172.683	
				2	-1065.472	2148.944	2183.665398	2217.723105	2653.379	0.001439
Model 4	intercept	class-specific	fixed	1	-1071.274	2150.548	2165.979733	2181.116491	2170.374	
				2	-1051.934	2119.868	2150.731465	2181.004982	2211.689	0.74619
				3	-1043.816	2111.632	2157.927198	2203.337473	2221.032	0.848618
				4	-1038.698	2109.396	2171.12293	2231.669965	2228.154	0.905767
Model 5	intercept, slope	class-specific	fixed	1	-1065.472	2142.944	2166.091599	2188.796737	2172.683	
				2	-1045.716	2115.433	2161.727198	2207.137473	2268.316	0.559699
Model 6	intercept	fixed	class-specific	1	-1071.274	2150.548	2165.979733	2181.116491	2170.374	
				2	-1028.1259	2072.252	2103.115265	2133.388782	2273.392	0.391305
Model 7	intercept,	fixed	class-	1	-1065.4718	2142.944	2166.091199	2188.796337	2172.683	

	slope		specific							
				2	-1027.3398	2074.68	2113.258932	2151.100828	2288.715	0.387465
Model 8	intercept	class-specific	class-specific	1	-1071.274	2150.548	2165.979733	2181.116491	2170.374	
				2	-1028.0928	2074.186	2108.906998	2142.964705	2279.634	0.391742
Model 9	intercept, slope	class-specific	class-specific	1	-1065.4718	2142.944	2166.091199	2188.796337	2172.683	

Table S10: Model fit statistics for growth mixture model (GMM) for scientific community values. Each GMM was fitted with one to nine classes. Only models for which a solution was possible are reported. The best model based on SABIC is highlighted in bold.

Model	Random effects	Random effects variance	Residual variance	Number of classes	Log-likelihood	AIC	BIC	SABIC	ICL	EIC
Model 1	null				-1203.222	2410.444	2418.148405	2423.508164	2420.346	
Model 2	intercept	fixed	fixed	1	-1114.611	2237.223	2252.63081	2263.350327	2257.041	
				2	-1065.326	2144.651	2171.617417	2190.376573	2191.424	0.945222
				3	-1065.315	2150.631	2189.152025	2215.950818	2582.392	0.375731
				4	-1030.106	2086.212	2136.290632	2171.129063	2238.231	0.806296
Model 3	intercept, slope	fixed	fixed	1	-1089.69	2191.381	2214.493215	2230.572491	2221.086	
				2	-1089.69	2197.379	2232.049822	2256.168736	2674.313	0.00525
				3	no solution					
				4	-1089.684	2209.367	2267.151037	2307.349227	3176.337	0.002
Model 4	intercept	class-specific	fixed	1	-1108.317	2224.634	2240.04281	2250.762327	2244.437	
				2	-1058.519	2133.037	2163.85562	2185.294654	2185.177	0.941824
				3	-1033.855	2091.711	2137.93643	2170.094982	2270.385	0.68437
				4	-1017.281	2066.562	2128.19724	2171.075309	2291.312	0.692057
				5	-1009.073	2058.146	2135.19005	2188.787636	2313.332	0.708929
				6	-1005.799	2059.598	2152.05086	2216.367963	2338.11	0.731869
				7	-1003.703	2063.406	2171.267669	2246.304291	2357.977	0.759165

Model 5	intercept, slope	class- specific	fixed	1	-1089.69	2191.381	2214.493215	2230.572491	2221.086	
				2	-1026.732	2077.465	2123.69043	2155.848982	2223.919	0.651584
Model 6	intercept	fixed	class- specific	1	-1108.3171	2224.634	2240.04301	2250.762527	2244.437	
				2	-994.0373	2004.075	2034.89222	2056.331254	2120.156	0.655708
Model 7	intercept, slope	fixed	class- specific	1	-1089.6904	2191.381	2214.494015	2230.573291	2221.086	
				2	-992.8258	2005.652	2044.173625	2070.972418	2133.084	0.650814
Model 8	intercept	class- specific	class- specific	1	-1114.6113	2237.223	2252.63141	2263.350927	2257.041	
				2	-999.9397	2017.879	2052.549222	2076.668136	2133.677	0.677282
Model 9	intercept, slope	class- specific	class- specific	1	-1096.5473	2205.095	2228.207815	2244.287091	2234.822	
				2	-990.4382	2006.876	2056.955032	2091.793463	2144.484	0.668715

Table S11: Effects of demographic factors on measures of student affect based on mixed effects models. Parameter estimates were calculated where PEERs = yes, female/male = male, and first-generation = yes. Significant parameters are indicated in bold.

Self-efficacy					
Cluster 1 (N=22)					
	Estimate	SE	df	X ²	P
Intercept	2.60	0.58	20.47	1	<0.001
time	0.41	0.27	2.37	1	0.12
PEERs	-1.53	1.04	2.17	1	0.14
female/male	1.09	1.02	1.14	1	0.28
first-generation	1.54	1.10	1.95	1	0.16
time x PEERs	0.53	0.48	1.19	1	0.28
time x female/male	-0.62	0.47	1.73	1	0.19
time x first-generation	-0.66	0.51	1.69	1	0.19
Cluster 2 (N=297)					
	Estimate	SE	df	X ²	P
Intercept	3.68	0.06	3537.56	1	<0.001
time	0.25	0.03	96.25	1	<0.001
PEERs	-0.23	0.11	4.77	1	0.03
female/male	0.19	0.09	4.15	1	0.04
first-generation	-0.003	0.11	0.001	1	0.98
time x PEERs	0.03	0.04	0.35	1	0.55
time x female/male	-0.03	0.04	0.55	1	0.46
time x first-generation	-0.002	0.05	0.002	1	0.96
Science identity					
Cluster 1 (N=19)					
	Estimate	SE	df	X ²	P
Intercept	3.25	0.32	101.69	1	<0.001
time	-0.39	0.13	8.43	1	0.004
PEERs	-0.42	0.82	0.27	1	0.60
female/male	0.60	0.52	1.30	1	0.25
first-generation	0.25	0.77	0.11	1	0.74
time x PEERs	0.07	0.34	0.04	1	0.83
time x female/male	-0.13	0.22	0.36	1	0.55
time x first-generation	-0.05	0.32	0.02	1	0.88
Cluster 2 (N=301)					
	Estimate	SE	df	X ²	P
Intercept	3.57	0.07	2398.11	1	<0.001
time	0.18	0.03	36.70	1	<0.001
PEERs	-0.04	0.12	0.10	1	0.75

female/male	0.22	0.11	4.13	1	0.04
first-generation	0.01	0.13	0.005	1	0.95
time x PEERs	-0.07	0.05	1.96	1	0.16
time x female/male	-0.03	0.04	0.61	1	0.43
time x first-generation	0.001	0.05	0.0002	1	0.99
Scientific community values					
Cluster 1					
	Estimate	SE	df	X ²	P
Intercept	5.56	0.06	1	9020.31	<0.001
time	0.02	0.03	1	0.76	0.38
PEERs	0.09	0.10	1	0.84	0.36
female/male	0.03	0.09	1	0.08	0.78
first-generation	-0.08	0.11	1	0.55	0.46
time x PEERs	-0.07	0.04	1	2.42	0.12
time x female/male	-0.002	0.04	1	0.003	0.96
time x first-generation	0.02	0.05	1	0.23	0.63
Cluster 2					
	Estimate	SE	df	X ²	P
Intercept	4.80	0.17	1	836.43	<0.001
time	-0.14	0.08	1	3.09	0.08
PEERs	0.32	0.28	1	1.31	0.25
female/male	-0.18	0.23	1	0.58	0.45
first-generation	-0.15	0.28	1	0.27	0.60
time x PEERs	-0.12	0.13	1	0.91	0.34
time x female/male	0.09	0.11	1	0.74	0.39
time x first-generation	0.13	0.13	1	1.04	0.31

Table S12: Correlations between measures of student affect at the beginning, middle, and end of a two-semester introductory biology sequence

	self_efficacy_1	self_efficacy_2	self_efficacy_3	science_identity_1	science_identity_2	science_identity_3	community_1	community_2	community_3
self_efficacy_1	1	0.28	0.32	0.50	0.33	0.29	0.25	0.25	0.22
self_efficacy_2	0.28	1	0.40	0.34	0.52	0.40	0.28	0.48	0.38
self_efficacy_3	0.32	0.40	1	0.25	0.35	0.55	0.27	0.38	0.58
science_identity_1	0.50	0.34	0.25	1	0.59	0.49	0.43	0.40	0.34
science_identity_2	0.33	0.52	0.35	0.59	1	0.61	0.37	0.60	0.42
science_identity_3	0.29	0.40	0.55	0.49	0.61	1	0.32	0.47	0.65
community_1	0.25	0.28	0.27	0.43	0.37	0.32	1	0.47	0.35
community_2	0.25	0.48	0.38	0.40	0.60	0.47	0.47	1	0.54
community_3	0.22	0.38	0.58	0.34	0.42	0.65	0.35	0.54	1