Profiles of STEM Students: Persisters, Joiners, Changers and Departers

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Abstract

This study is an extension of two previous studies that provided profiles of persisting STEM majors overall (regardless of academic performance) and persisting STEM majors who earned semester GPAs of 3.0 or higher (Westrick, 2016, 2017). Using data from 25 four-year institutions, this study compared the mean ACT assessment scores, HSGPAs, and ACT Interest Inventory scores between four groups of students: 1) those who persisted in a STEM field over eight semesters, 2) students who later joined the STEM field, 3) those who started in a STEM field but changed to another field, and 4) students who started in a STEM field but had departed their institution before the end of the fourth year. In this study more than 60 percent of the students who started as STEM majors changed majors or left school. While the students who persisted in or joined the STEM fields had higher mean ACT scores and HSGPAs than those for the students who left STEM fields or the institution, the four groups had similar measured interests.

Background

High rates of student attrition in STEM fields are well documented (Chen, 2009, 2013), as are efforts to increase the number of students in the STEM pipeline by raising students' interest in STEM fields (Government Accountability Office, 2012; Venkataraman, Riordian, & Olson, 2010; White House, Office of the Press Secretary, 2009). Research indicates that high levels of precollege academic achievement are associated with students choosing STEM majors when they enter college and also with persistence and STEM degree completion (Radunzel, Mattern, & Westrick, 2016). Research also suggests that expressed and measured interests contribute to the prediction of STEM major choice, persistence, and degree completion, though less than do measures of precollege academic achievement (Radunzel et al., 2016).

This study is the third in a series examining the precollege academic achievement levels and measured interests of STEM majors. The first study (Westrick, 2016) established that students who declare a STEM major enter college with higher mean ACT scores and high school grade point averages (HSGPAs) than do students who choose non-STEM majors. Standardized mean differences (δ, Cohen, 1988) between the precollege academic achievement levels for the STEM and non-STEM students were of practical significance in the first semester and increased for students who persisted through the following seven semesters. It was also established that even after collapsing numerous majors into three student major categories (SMCs) – STEM-Biological, STEM-Quantitative, and non-STEM – the two STEM groups had unique ACT Interest Inventory score profiles. The second study (Westrick, 2017) established that among students in STEM majors, those earning postsecondary semester grade point averages (SGPAs) of 3.0 or higher had entered college with higher mean ACT scores and HSGPAs than did the students in STEM majors earning SGPAs less than 3.0. Furthermore, within each STEM SMC, the standardized mean differences between the precollege academic measures of high performing and lower-performing students were of practical significance. However, there were no differences of practical significance in the measured interests of students earning SGPAs of 3.0 or higher and those earning SGPAs less than 3.0 within each STEM SMC.

The first two studies also presented profiles of persisting STEM students. In the overall analyses (Westrick, 2016), students in the STEM-Biological and STEM-Quantitative SMCs who persisted through the eighth semester had mean ACT mathematics scores of 25 and 26, respectively, and mean ACT science scores of 25 and 26, respectively. The second study provided profiles of highly successful STEM majors, those who had earned SGPAs of 3.0 or higher consecutively in semesters five through eight. These students had ACT scores that were even higher, with mean ACT mathematics and science scores of 27 and 26, respectively, for the highly successful STEM-Biological majors, and 29 and 27, respectively, for the STEM-Quantitative majors. Follow-up analyses found that mean ACT STEM scores for all STEM majors who persisted through the eighth semester in the first study was 26, as was the mean ACT STEM score for the STEM students who earned SGPAs of 3.0 or higher in the first semester in the second study. These scores match the ACT STEM readiness benchmark of 26, the ACT STEM score associated with a reasonable chance of success in first-year STEM-identified mathematics and science courses (Radunzel, Mattern, Crouse, & Westrick, 2015). The mean STEM score for the highly successful STEM majors, those with SGPAs of 3.0 or higher from the fifth through the eighth semesters, was 27.

A planned extension of the first two studies was to examine student migration into and out of the STEM SMCs. Its purpose was to determine if there were differences of practical significance between four types of students: the students who were in the same STEM SMC in the first and eighth semesters (persisters); students who started in a different SMC in the first semester but had joined a STEM SMC by the eighth semester (joiners); students who started in one of the STEM SMCs in the first semester but had changed to another SMC by the eighth semester (changers); and students who had started in one of the STEM SMCs in the first semester but had dropped out, stopped out, or transferred by the eighth semester (departers).[1]

Previous research has found that admission test scores and HSGPA are positively correlated with retention (Mattern & Patterson, 2011; Westrick, Le, Robbins, Radunzel, & Schmidt, 2015). This pattern was found in the first and second studies in this series. Therefore, an expected outcome of the current study was that the mean ACT scores and HSGPAs of the students who persisted in or joined a STEM SMC would be higher than the means associated with the students who departed the institution. Similarly, a lack of academic preparedness may also explain why some students changed from a STEM SMC to another STEM or non-STEM SMC. However, another possible antecedent is a misalignment of the students' measured interests and the interest profiles of their initial majors. Results of the first study indicated that the mean ACT Interest Inventory scores of the enrolled STEM students were relatively stable as the number of students decreased over time, suggesting that the measured interests of the students who migrated to another SMC or left the institution differed little from the students who persisted in or joined that STEM SMC. However, combining the students who changed majors and remained enrolled with students who departed the institution possibly obscures key differences between these two groups. Combining the students who declared a STEM major in the first semester and persisted in a STEM major into the eighth semester with students who declared a STEM major between the second and eighth semester may also mask differences between these two groups. It was of interest to see if the differences in the precollege academic achievement levels and the measured interests of the students in the four classifications were of practical significance, especially among the students who migrated into or out of a STEM SMC.

Data came from 27,516 students[2] who enrolled as first-time students in the fall term between 2000 and 2005 (six cohort years) at 25 four-year institutions. The dataset used in the current study is a subset of the dataset used in the previous studies (Westrick, 2016, 2017). Because the institution is the unit of analysis, each institution had to have students in each of the four categories to be included in the meta-analyses. One institution that had been included in the first two studies did not have students in each of the four categories (persisters, joiners, changers, and departers), so data from that institution was excluded from this study.[3]

Incoming students were classified according to their declared majors using the two-digit Classification of Instructional Program (CIP) codes (National Center for Education Statistics,

[1] The analyses were based on students declared majors in the first and eighth semesters. Some students changed their majors more than once. Presenting all the paths students took across eight semesters is not done here as it would lengthen this report considerably and distract from the main thrust of this report.

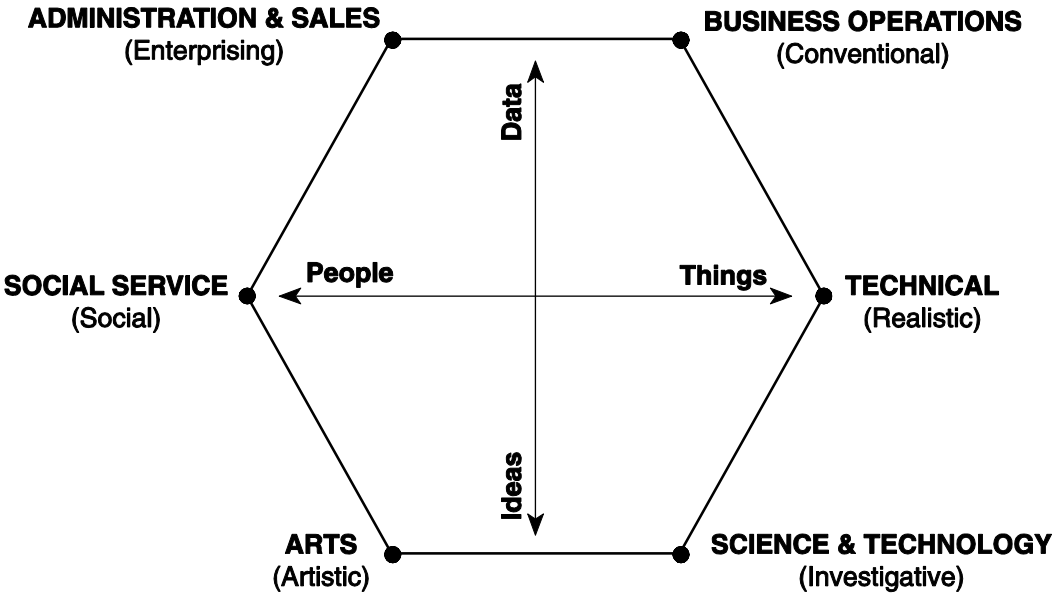
[2] Among the students who changed SMCs, 151 switched from STEM-Biological to STEM-Quantitative and 472 switched from STEM-Quantitative to STEM-Biological. There were too few observations in these two categories across institutions for separate analyses, and they were included with the students who migrated into or out of non-STEM academic majors. These 623 students are included in the meta-analyses for both STEM SMCs, as "changers" in their original STEM SMC and as "joiners" in their final STEM SMC.

[3] In the first semester, this institution had 607 students, of which 35 were in the STEM-Biological SMC and 35 were in the STEM-Quantitative SMC. In the eighth semester, there were 17 in the STEM-Biological SMC and 18 in the STEM-Quantitative SMC.

2002). Students with a CIP code of 26 (Biological and Biomedical Sciences) were classified as STEM-Biological. Students with CIPs of 11 (Computer Sciences), 14 (Engineering), 27 (Mathematics and Statistics), and 40 (Physical Sciences) were classified as STEM-Quantitative. All other students were classified as non-STEM. Students were classified again in the eighth semester according to their declared majors. Only the students who had been in a STEM SMC in the first semester or in a STEM SMC in the eighth semester were included.

The measures in the current study are ACT test scores, HSGPA, ACT Interest Inventory scores, and SGPA. The ACT test is a battery of four tests – English (ACTE), mathematics (ACTM), reading (ACTR), and science (ACTS) – with a Composite (ACTC) score that is the average score of the four tests (ACT, 2014). All scores are reported on a scale from 1 to 36.[4] The measure of HSGPA in this study is based on students' self-reported high school grades in four core subject areas: English, mathematics, social science, and natural science. HSGPA is reported on a scale from 0 to 4. The ACT Interest Inventory is a wideband measure intended for use in career exploration (ACT, 2009). Data were collected when the students registered for the ACT test in high school. The inventory provides scores on six basic types of vocational interests paralleling six career types in Holland's (1997) theory of careers. The six vocational interests with Holland's types in parentheses are: Science & Technology (Investigative), Arts (Artistic), Social Service (Social), Administration & Sales (Enterprising), Business Operations (Conventional), and Technical (Realistic). ACT Interest Inventory scale scores range from 20 to 80. Research has shown (ACT, 2009) that two dimensions, Data/Ideas (DI) and People/Things (PT) underlie job analysis ratings and measured interests of Holland-type career groups (Figure 1). ACT Interest Inventory scores can be converted to DI and PT scores.[5] As in the previous study, DI and PT scores are examined in the current study.

Figure 1. Relationship between interest scales (Holland types) and work task dimensions



[4] The optional ACT Writing Test is reported on a scale from 2 to 12.

[5] DI = 0(Realistic) – 1.73(Investigative) – 1.73(Artistic) + 0(Social) + 1.73(Enterprising) + 1.73(Conventional) and PT = 2(Realistic) + 1(Investigative) – 1(Artistic) – (Social) – 1(Enterprising) + 1(Conventional). Source: The ACT Interest Inventory Technical Manual (ACT, 2009).

As this study aimed to make comparisons between four groups of students within each of the STEM SMCs, there were six group comparisons examined: persisted—departed, persisted—changed, persisted—joined, joined—departed, joined—changed, and changed—departed. Standardized mean differences (δ, Cohen, 1988) were calculated for each measure at each institution, and the institutional results were then meta-analyzed (Schmidt & Hunter, 2015). Standardized mean differences greater than or equal to |0.20| with 80% credibility intervals that do not contain zero are considered to be of practical significance and are presented in bold text within the tables. Standardized mean differences can be converted to correlations, and they provide validity evidence much as correlations do (Schmidt & Hunter, 2015). However, standardized mean differences allow comparisons between the means for different groups. For example, if the pooled standard deviation on a measure is 5 and the standardized mean difference between two groups is 0.60, multiplying the effect size (0.60) by the pooled standard deviation (5) indicates that the difference between the mean scores for the two groups is 3.

As in the two preceding reports, ACT test score, HSGPA, and ACT Interest Inventory score profiles are presented in this report. These profiles contain the mean scores and HSGPAs for the students in each of the four classifications within the two STEM SMCs.

Results

Descriptive Statistics

Tables 1 (ACT scores and HSGPA) and 2 (ACT Interest Inventory scores) contain the descriptive statistics for all students in the four groups within each STEM SMC. The general pattern in both STEM SMCs was the mean ACT scores and HSGPAs were highest for the students who were in the same SMC in the first and eighth semesters, followed by the students who had joined the STEM SMC after the first semester, followed by the students who had changed to a major outside of the SMC, and lastly by the students who had departed the institution. Unlike the precollege academic achievement measures, the differences between the groups' Interest Inventory scores and the work-task dimension scores did not display a consistent pattern.

Table 1: Means and Standard Deviations for ACT Scores and HSGPA for STEM Majors Based on First to Eighth Semester STEM Enrollment Status

		STEM-Biological			STEM-Quantitative		
Measure	**Group**	***N***	***M***	***SD***	***N***	***M***	***SD***
ACT Composite	Departed	3,601	22.6	4.0	5,696	24.0	4.3
	Changed	2,597	23.8	3.8	3,797	24.8	4.1
	Joined	2,159	25.1	3.9	1,317	25.0	4.1
	Persisted	2,984	25.6	3.9	5,988	26.6	4.0
ACT English	Departed	3,601	22.6	4.9	5,696	23.1	5.0
	Changed	2,597	24.0	4.6	3,797	24.3	4.9
	Joined	2,159	25.2	4.8	1,317	24.4	5.0
	Persisted	2,984	25.7	4.7	5,988	25.8	4.9
ACT Mathematics	Departed	3,601	21.9	4.4	5,696	24.5	4.8
	Changed	2,597	23.3	4.3	3,797	25.3	4.5
	Joined	2,159	25.0	4.3	1,317	25.9	4.5
	Persisted	2,984	25.6	4.3	5,988	27.8	4.2
ACT Reading	Departed	3,601	23.0	5.4	5,696	23.8	5.6
	Changed	2,597	24.2	5.3	3,797	24.7	5.5
	Joined	2,159	25.3	5.4	1,317	24.7	5.6
	Persisted	2,984	25.9	5.3	5,988	26.0	5.5
ACT Science	Departed	3,601	22.2	3.9	5,696	23.9	4.4
	Changed	2,597	23.2	3.8	3,797	24.4	4.2
	Joined	2,159	24.3	4.0	1,317	24.7	4.2
	Persisted	2,984	24.7	4.0	5,988	26.1	4.4
HSGPA	Departed	3,601	3.49	0.46	5,696	3.46	0.47
	Changed	2,597	3.66	0.36	3,797	3.65	0.38
	Joined	2,159	3.75	0.32	1,317	3.67	0.39
	Persisted	2,984	3.78	0.30	5,988	3.76	0.31

Note: Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Table 2: Means and Standard Deviations for Interest Inventory and Work Task Dimension Scores for STEM Majors Based on First to Eighth Semester STEM Enrollment Status

		STEM-Biological			STEM-Quantitative		
Measure	**Group**	***N***	***M***	***SD***	***N***	***M***	***SD***
Science & Technology	Departed	3,601	58.7	9.3	5,696	56.3	9.0
	Changed	2,597	58.9	8.5	3,797	56.2	8.8
	Joined	2,159	59.0	8.6	1,317	56.6	9.0
	Persisted	2,984	61.0	8.8	5,988	57.3	8.5
Arts	Departed	3,601	50.6	9.3	5,696	51.2	9.1
	Changed	2,597	51.1	9.2	3,797	51.3	8.9
	Joined	2,159	51.2	9.3	1,317	51.8	9.2
	Persisted	2,984	51.4	9.4	5,988	51.0	8.7
Social Service	Departed	3,601	52.1	10.8	5,696	49.4	10.9
	Changed	2,597	53.5	10.9	3,797	50.8	10.9
	Joined	2,159	51.7	10.6	1,317	49.6	10.5
	Persisted	2,984	52.8	10.6	5,988	49.4	10.4
Administration & Sales	Departed	3,601	49.4	8.7	5,696	51.8	8.5
	Changed	2,597	49.3	8.6	3,797	51.6	8.6
	Joined	2,159	49.8	8.5	1,317	51.5	8.6
	Persisted	2,984	49.6	8.7	5,988	52.5	8.5
Business Operations	Departed	3,601	49.9	9.9	5,696	50.6	9.5
	Changed	2,597	51.0	9.8	3,797	51.1	9.4
	Joined	2,159	49.8	9.4	1,317	50.0	9.4
	Persisted	2,984	50.0	9.5	5,988	50.4	9.2
Technical	Departed	3,601	50.8	9.7	5,696	54.8	9.5
	Changed	2,597	50.7	9.6	3,797	53.7	9.5
	Joined	2,159	51.5	9.8	1,317	53.6	9.6
	Persisted	2,984	51.5	10.0	5,988	55.3	9.4
People-Things	Departed	3,601	4.9	30.2	5,696	17.0	29.8
	Changed	2,597	0.5	30.4	3,797	11.2	30.6
	Joined	2,159	7.3	31.2	1,317	14.4	30.3
	Persisted	2,984	6.6	30.4	5,988	20.1	30.3
Data-Ideas	Departed	3,601	-17.4	32.3	5,696	-8.9	31.0
	Changed	2,597	-16.8	31.4	3,797	-8.5	31.7
	Joined	2,159	-18.3	31.1	1,317	-12.0	32.0
	Persisted	2,984	-22.2	32.0	5,988	-9.2	31.3

Note: Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Standardized Mean Differences in Precollege Academic Achievement Levels

Tables 3a and 3b contain the meta-analytic results for the comparisons made between the STEM-Biological groups. The students who persisted in a STEM-Biological major had higher mean ACT scores and HSGPAs than the students who changed to a major outside of the Biological/Biomedical sciences or departed the institution after the first semester. All the effect sizes for standardized mean differences were of practical significance, ranging from 0.37 (persisted—changed, ACTR) to 0.71 (persisted—departed, ACTM). Students who had persisted in the Biological/Biomedical sciences also had higher mean ACT scores and HSGPAs than those for the students who had not initially declared a Biological/Biomedical science major in the first semester but later joined the STEM-Biological SMC, though none of the effect sizes exceeded 0.20 and most of the credibility intervals contained zero. All the effect sizes for the comparisons between the students who had joined the STEM-Biological SMC and those who had departed were of practical significance, ranging from 0.35 to 0.66. Likewise, the joiners also had higher mean ACT scores and HSGPAs than those for the students who had changed from the Biological/Biomedical sciences to another SMC, but not all the effect sizes exceeded 0.20. An interesting pattern was that the largest effect size for all the sets of comparisons made between current STEM-Biological majors (persisters and joiners) and those who had left the SMC (changers and departers) were for the ACT mathematics comparisons, ranging from 0.51 (joined—changed) to 0.71 (persisted—departed). Finally, the students who had changed from the STEM-Biological SMC to another SMC had higher mean ACT scores and HSGPAs than those for the STEM-Biological students who had departed before the eighth semester, but only the effect sizes for the ACT English (0.20) and HSGPA (0.28) comparisons were of practical significance.

Table 3a: Estimated Mean Effect Sizes for STEM-Biological Migration Analyses, ACT Scores and HSGPAs

Group 1	Group 2	Variable	*k*	*N*	δ	*SD*δ	80% CrI
Persisted	Departed	ACT Composite	25	6,585	**0.66**	0.18	**[0.43, 0.88]**
		ACT English	25	6,585	**0.59**	0.20	**[0.34, 0.84]**
		ACT Mathematics	25	6,585	**0.71**	0.15	**[0.52, 0.90]**
		ACT Reading	25	6,585	**0.49**	0.18	**[0.26, 0.72]**
		ACT Science	25	6,585	**0.60**	0.14	**[0.42, 0.78]**
		HSGPA	25	6,585	**0.70**	0.11	**[0.55, 0.84]**
Persisted	Changed	ACT Composite	25	5,581	**0.50**	0.11	**[0.37, 0.64]**
		ACT English	25	5,581	**0.41**	0.13	**[0.25, 0.57]**
		ACT Mathematics	25	5,581	**0.58**	0.17	**[0.36, 0.80]**
		ACT Reading	25	5,581	**0.37**	0.11	**[0.24, 0.51]**
		ACT Science	25	5,581	**0.46**	0.05	**[0.40, 0.52]**
		HSGPA	25	5,581	**0.44**	0.19	**[0.20, 0.68]**
Persisted	Joined	ACT Composite	25	5,143	0.16	0.16	[-0.04, 0.36]
		ACT English	25	5,143	0.15	0.17	[-0.06, 0.36]
		ACT Mathematics	25	5,143	0.08	0.09	[-0.03, 0.19]
		ACT Reading	25	5,143	0.17	0.10	[0.04, 0.30]
		ACT Science	25	5,143	0.15	0.15	[-0.04, 0.34]
		HSGPA	25	5,143	0.16	0.00	[0.16, 0.16]

Note. Bold indicates that the estimated mean effect size (δ) exceeds |0.20| and the credibility interval (CrI) does not contain zero. *k* = number of institutional studies; *SD*δ = standard deviation of estimated mean effect size; Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Table 3b: Estimated Mean Effect Sizes for STEM-Biological Migration Analyses, ACT Scores and HSGPAs

Group 1	Group 2	Variable	*k*	*N*	δ	*SD*δ	80% CrI
Joined	Departed	ACT Composite	25	5,760	**0.54**	0.19	**[0.29, 0.79]**
		ACT English	25	5,760	**0.48**	0.17	**[0.26, 0.70]**
		ACT Mathematics	25	5,760	**0.66**	0.15	**[0.47, 0.85]**
		ACT Reading	25	5,760	**0.35**	0.12	**[0.20, 0.50]**
		ACT Science	25	5,760	**0.50**	0.20	**[0.24, 0.76]**
		HSGPA	25	5,760	**0.54**	0.17	**[0.33, 0.76]**
Joined	Changed	ACT Composite	25	4,756	**0.34**	0.12	**[0.18, 0.49]**
		ACT English	25	4,756	**0.26**	0.12	**[0.10, 0.41]**
		ACT Mathematics	25	4,756	**0.51**	0.13	**[0.35, 0.67]**
		ACT Reading	25	4,756	0.18	0.03	[0.14, 0.22]
		ACT Science	25	4,756	**0.31**	0.14	**[0.13, 0.49]**
		HSGPA	25	4,756	0.26	0.21	[0.00, 0.53]
Changed	Departed	ACT Composite	25	6,198	0.17	0.00	[0.17, 0.17]
		ACT English	25	6,198	**0.20**	0.04	**[0.15, 0.25]**
		ACT Mathematics	25	6,198	0.17	0.13	[0.01, 0.34]
		ACT Reading	25	6,198	0.11	0.00	[0.11, 0.11]
		ACT Science	25	6,198	0.17	0.06	[0.10, 0.25]
		HSGPA	25	6,198	**0.28**	0.16	**[0.08, 0.47]**

Note. Bold indicates that the estimated mean effect size (δ) exceeds |0.20| and the credibility interval (CrI) does not contain zero. *k* = number of institutional studies; *SD*δ = standard deviation of estimated mean effect size; Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Results for the comparisons made between the STEM-Quantitative majors were in many ways similar to those for the STEM-Biological comparisons, but there were some differences worth noting (Tables 4a and 4b). Students who persisted in the quantitative fields had higher mean ACT scores and HSGPAs than those for the students who had departed or had changed to a major outside of the STEM-Quantitative SMC, with effect sizes ranging from 0.24 (persisted—changed, ACTR) to 0.69 (persisted—departed, HSGPA). Note that the effect sizes for the ACT mathematics comparisons were the largest effect sizes for ACT scores (0.61, persisted—changed; 0.63, persisted—departed). The persisting STEM-Quantitative majors also had higher mean ACT scores and HSGPAs than those for the students who had joined the SMC by the eighth semester. Unlike the results found in the STEM-Biological comparisons, all the effect sizes for the persisted—joined comparisons for the STEM-Quantitative majors were of practical significance, ranging from 0.22 (ACTR) to 0.39 (ACTM).

Table 4a: Estimated Mean Effect Sizes for STEM-Quantitative Migration Analyses, ACT Scores and HSGPAs

Group 1	Group 2	Variable	*k*	*N*	δ	*SD*δ	80% CrI
Persisted	Departed	ACT Composite	25	11,684	**0.49**	0.11	**[0.35, 0.62]**
		ACT English	25	11,684	**0.45**	0.14	**[0.27, 0.62]**
		ACT Mathematics	25	11,684	**0.63**	0.08	**[0.53, 0.73]**
		ACT Reading	25	11,684	**0.30**	0.10	**[0.18, 0.42]**
		ACT Science	25	11,684	**0.43**	0.09	**[0.31, 0.55]**
		HSGPA	25	11,684	**0.69**	0.12	**[0.54, 0.84]**
Persisted	Changed	ACT Composite	25	9,785	**0.42**	0.00	**[0.42, 0.42]**
		ACT English	25	9,785	**0.31**	0.04	**[0.26, 0.36]**
		ACT Mathematics	25	9,785	**0.61**	0.00	**[0.61, 0.61]**
		ACT Reading	25	9,785	**0.24**	0.03	**[0.21, 0.27]**
		ACT Science	25	9,785	**0.42**	0.05	**[0.36, 0.48]**
		HSGPA	25	9,785	**0.35**	0.13	**[0.19, 0.51]**
Persisted	Joined	ACT Composite	25	7,305	**0.32**	0.14	**[0.14, 0.50]**
		ACT English	25	7,305	**0.25**	0.11	**[0.11, 0.39]**
		ACT Mathematics	25	7,305	**0.39**	0.14	**[0.21, 0.58]**
		ACT Reading	25	7,305	**0.22**	0.15	**[0.03, 0.41]**
		ACT Science	25	7,305	**0.32**	0.12	**[0.17, 0.48]**
		HSGPA	25	7,305	**0.28**	0.13	**[0.11, 0.44]**

Note. Bold indicates that the estimated mean effect size (δ) exceeds |0.20| and the credibility interval (CrI) does not contain zero. *k* = number of institutional studies; *SD*δ = standard deviation of estimated mean effect size; Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Table 4b: Estimated Mean Effect Sizes for STEM-Quantitative Migration Analyses, ACT Scores and HSGPAs

Group 1	Group 2	Variable	*k*	*N*	δ	*SD*δ	80% CrI
Joined	Departed	ACT Composite	25	7,013	0.24	0.21	[-0.03, 0.51]
		ACT English	25	7,013	0.25	0.20	[-0.01, 0.51]
		ACT Mathematics	25	7,013	**0.30**	0.20	**[0.04, 0.56]**
		ACT Reading	25	7,013	0.15	0.18	[-0.09, 0.38]
		ACT Science	25	7,013	0.18	0.24	[-0.12, 0.48]
		HSGPA	25	7,013	**0.47**	0.17	**[0.25, 0.69]**
Joined	Changed	ACT Composite	25	5,114	0.11	0.19	[-0.13, 0.35]
		ACT English	25	5,114	0.07	0.22	[-0.21, 0.36]
		ACT Mathematics	25	5,114	**0.23**	0.16	**[0.03, 0.43]**
		ACT Reading	25	5,114	0.02	0.13	[-0.14, 0.18]
		ACT Science	25	5,114	0.12	0.19	[-0.12, 0.36]
		HSGPA	25	5,114	0.09	0.17	[-0.13, 0.30]
Changed	Departed	ACT Composite	25	9,493	**0.08**	0.06	**[0.00, 0.15]**
		ACT English	25	9,493	0.14	0.10	[0.01, 0.27]
		ACT Mathematics	25	9,493	0.03	0.00	[0.03, 0.03]
		ACT Reading	25	9,493	0.08	0.05	[0.01, 0.14]
		ACT Science	25	9,493	0.02	0.13	[-0.15, 0.19]
		HSGPA	25	9,493	**0.36**	0.11	**[0.22, 0.50]**

Note. Bold indicates that the estimated mean effect size (δ) exceeds |0.20| and the credibility interval (CrI) does not contain zero. *k* = number of institutional studies; *SD*δ = standard deviation of estimated mean effect size; Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Another difference in the STEM-Quantitative results was that the students who joined the SMC did not have much higher levels of precollege academic achievement when compared to the students who had departed or had changed to a major outside of the STEM-Quantitative SMC. Students who joined the STEM-Quantitative fields tended to have higher mean ACT scores and HSGPAs than those for the students who departed or changed to another SMC, but most of the credibility intervals contained zero due to the variability in results found across institutions. However, the one comparison that was of practical significance in both sets of comparisons was for ACT mathematics. The effect sizes were 0.30 and 0.23 for the joined-departed and joined-changed comparisons, respectively. Students who joined the STEM-Quantitative SMC also had higher mean HSGPAs than those for the departed students, with an effect size of 0.47. Finally, the only changed-departed comparison of practical significance was the HSGPA comparison (0.36).

Standardized Mean Differences in Measured Interests

Whereas the precollege academic achievement level differences between the students who persisted or joined the STEM SMCs and the students who changed out of the STEM SMCs or departed were often of practical significance, the results from the measured interest comparisons within each of the STEM SMCs indicated that the students in the four groups had rather similar interest levels. Starting with the results for the STEM-Biological majors in Tables 5a and 5b, none of the effect sizes for comparisons between the students who departed

and the other three groups exceeded |0.20|. Compared to the mean scores for students who changed from the STEM-Biological SMC to another SMC, students who persisted in the STEM-Biological SMC had higher mean scores on the Science & Technology scale (0.27) and on the People-Things work task dimension (0.21), but none of the other comparisons were of practical significance. For the persisted—joined comparisons, only the effect size for the Science & Technology scale (0.30) was of practical significance. For the comparisons between the mean scores for students who joined and the mean scores for those who had changed to another SMC, the only effect size of practical significance was for the People-Things comparison (0.21).

Table 5a: Estimated Mean Effect Sizes for STEM-Biological Migration Analyses, ACT Interest Inventory Scores and Calculated Work Task Dimension Scores

Group 1	Group 2	Variable	*k*	*N*	δ	*SD*δ	80% CrI
Persisted	Departed	Science & Technology	25	6,585	0.16	0.13	[0.00, 0.33]
		Arts	25	6,585	0.02	0.08	[-0.08, 0.12]
		Social Service	25	6,585	0.00	0.06	[-0.08, 0.07]
		Business Operations	25	6,585	-0.01	0.00	[-0.01, -0.01]
		Administration & Sales	25	6,585	-0.05	0.09	[-0.17, 0.07]
		Technical	25	6,585	0.04	0.00	[0.04, 0.04]
		People-Things	25	6,585	0.08	0.10	[-0.05, 0.20]
		Data-Ideas	25	6,585	-0.11	0.13	[-0.28, 0.05]
Persisted	Changed	Science & Technology	25	5,581	**0.27**	0.10	**[0.15, 0.39]**
		Arts	25	5,581	0.03	0.05	[-0.04, 0.09]
		Social Service	25	5,581	-0.08	0.08	[-0.19, 0.02]
		Business Operations	25	5,581	0.03	0.00	[0.03, 0.03]
		Administration & Sales	25	5,581	-0.12	0.10	[-0.25, 0.01]
		Technical	25	5,581	0.08	0.05	[0.02, 0.15]
		People-Things	25	5,581	**0.21**	0.13	**[0.05, 0.38]**
		Data-Ideas	25	5,581	-0.17	0.04	[-0.22, -0.12]
Persisted	Joined	Science & Technology	25	5,143	**0.30**	0.13	**[0.14, 0.47]**
		Arts	25	5,143	0.03	0.15	[-0.17, 0.22]
		Social Service	25	5,143	0.10	0.21	[-0.17, 0.36]
		Business Operations	25	5,143	-0.04	0.06	[-0.12, 0.04]
		Administration & Sales	25	5,143	0.00	0.17	[-0.22, 0.21]
		Technical	25	5,143	-0.02	0.00	[-0.02, -0.02]
		People-Things	25	5,143	-0.01	0.15	[-0.21, 0.19]
		Data-Ideas	25	5,143	-0.17	0.00	[-0.17, -0.17]

Note. Bold indicates that the estimated mean effect size (δ) exceeds |0.20| and the credibility interval (CrI) does not contain zero. *k* = number of institutional studies; *SD*δ = standard deviation of estimated mean effect size; Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Table 5b: Estimated Mean Effect Sizes for STEM-Biological Migration Analyses, ACT Interest Inventory Scores and Calculated Work Task Dimension Scores

Group 1	Group 2	Variable	*k*	*N*	δ	*SD*δ	80% CrI
Joined	Departed	Science & Technology	25	5,760	-0.10	0.17	[-0.32, 0.12]
		Arts	25	5,760	0.00	0.18	[-0.23, 0.23]
		Social Service	25	5,760	-0.11	0.24	[-0.42, 0.19]
		Business Operations	25	5,760	0.03	0.00	[0.03, 0.03]
		Administration & Sales	25	5,760	-0.07	0.11	[-0.21, 0.07]
		Technical	25	5,760	0.08	0.00	[0.08, 0.08]
		People-Things	25	5,760	0.12	0.14	[-0.06, 0.30]
		Data-Ideas	25	5,760	0.02	0.00	[0.02, 0.02]
Joined	Changed	Science & Technology	25	4,756	-0.02	0.04	[-0.07, 0.02]
		Arts	25	4,756	0.01	0.00	[0.01, 0.01]
		Social Service	25	4,756	-0.15	0.16	[-0.36, 0.05]
		Business Operations	25	4,756	0.08	0.00	[0.08, 0.08]
		Administration & Sales	25	4,756	-0.11	0.00	[-0.11, -0.11]
		Technical	25	4,756	0.11	0.04	[0.06, 0.16]
		People-Things	25	4,756	**0.21**	0.05	**[0.15, 0.27]**
		Data-Ideas	25	4,756	-0.01	0.06	[-0.08, 0.06]
Changed	Departed	Science & Technology	25	6,198	-0.10	0.00	[-0.10, -0.10]
		Arts	25	6,198	0.00	0.00	[0.00, 0.00]
		Social Service	25	6,198	0.07	0.10	[-0.05, 0.21]
		Business Operations	25	6,198	-0.03	0.00	[-0.03, -0.03]
		Administration & Sales	25	6,198	0.07	0.00	[0.07, 0.07]
		Technical	25	6,198	-0.03	0.00	[-0.03, -0.03]
		People-Things	25	6,198	-0.12	0.00	[-0.12, -0.12]
		Data-Ideas	25	6,198	0.06	0.06	[-0.01, 0.14]

Note. Bold indicates that the estimated mean effect size (δ) exceeds |0.20| and the credibility interval (CrI) does not contain zero. *k* = number of institutional studies; *SD*δ = standard deviation of estimated mean effect size; Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Among the results for STEM-Quantitative majors in Tables 6a and 6b, the similarities between the measured interests of the four groups were even more noticeable. Only two effect sizes were of practical significance, both on the People-Things work task dimension (persisted—changed, 0.30; persisted—joined, 0.24). None of the effect sizes for comparisons made on the six Interest Inventory scales was of practical significance.

Table 6a: Estimated Mean Effect Sizes for STEM-Quantitative Migration Analyses, ACT Interest Inventory Scores and Calculated Work Task Dimension Scores

Group 1	Group 2	Variable	*k*	*N*	δ	*SD*δ	80% CrI
Persisted	Departed	Science & Technology	25	11,684	0.04	0.00	[0.04, 0.04]
		Arts	25	11,684	-0.08	0.07	[-0.17, 0.01]
		Social Service	25	11,684	-0.07	0.07	[-0.17, 0.03]
		Business Operations	25	11,684	0.06	0.00	[0.06, 0.06]
		Administration & Sales	25	11,684	-0.07	0.00	[-0.07, -0.07]
		Technical	25	11,684	0.01	0.00	[0.01, 0.01]
		People-Things	25	11,684	0.12	0.08	[0.02, 0.23]
		Data-Ideas	25	11,684	0.01	0.05	[-0.05, 0.07]
Persisted	Changed	Science & Technology	25	9,785	0.12	0.08	[0.02, 0.22]
		Arts	25	9,785	-0.06	0.00	[-0.06, -0.06]
		Social Service	25	9,785	-0.15	0.08	[-0.25, -0.06]
		Business Operations	25	9,785	0.10	0.08	[0.01, 0.20]
		Administration & Sales	25	9,785	-0.09	0.00	[-0.09, -0.09]
		Technical	25	9,785	0.17	0.00	[0.17, 0.17]
		People-Things	25	9,785	**0.30**	0.00	**[0.30, 0.30]**
		Data-Ideas	25	9,785	-0.02	0.00	[-0.02, -0.02]
Persisted	Joined	Science & Technology	25	7,305	0.07	0.14	[-0.12, 0.25]
		Arts	25	7,305	-0.14	0.15	[-0.32, 0.05]
		Social Service	25	7,305	-0.08	0.03	[-0.12, -0.03]
		Business Operations	25	7,305	0.11	0.13	[-0.06, 0.28]
		Administration & Sales	25	7,305	0.00	0.05	[-0.06, 0.06]
		Technical	25	7,305	0.19	0.06	[0.12, 0.27]
		People-Things	25	7,305	**0.24**	0.05	**[0.18, 0.30]**
		Data-Ideas	25	7,305	0.08	0.11	[-0.05, 0.22]

Note. Bold indicates that the estimated mean effect size (δ) exceeds |0.20| and the credibility interval (CrI) does not contain zero. *k* = number of institutional studies; *SD*δ = standard deviation of estimated mean effect size; Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Table 6b: Estimated Mean Effect Sizes for STEM-Quantitative Migration Analyses, ACT Interest Inventory Scores and Calculated Work Task Dimension Scores

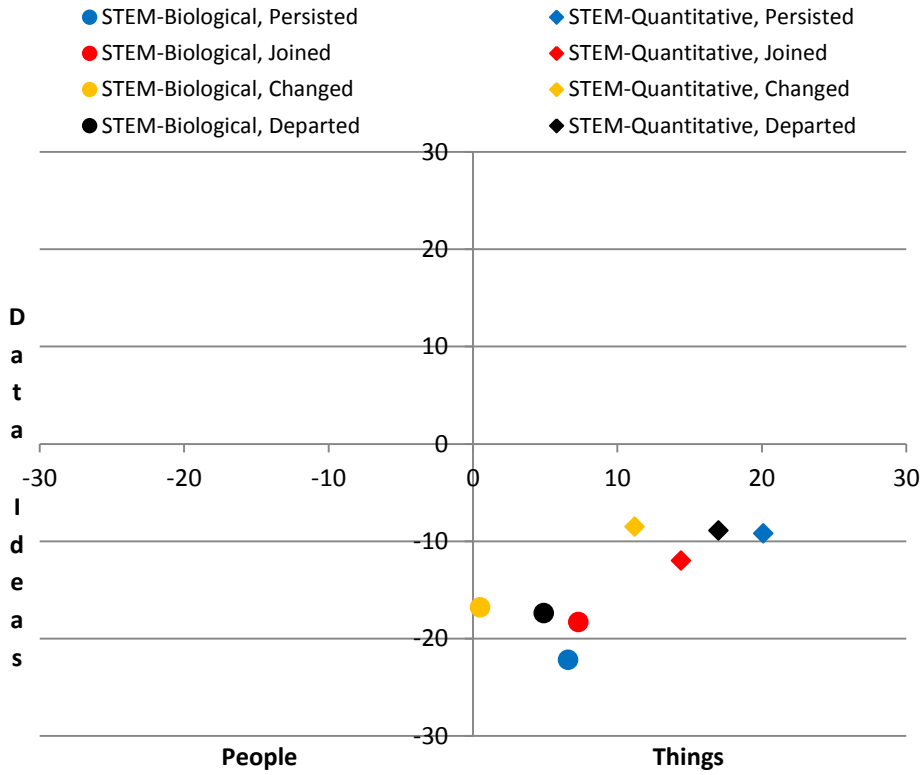
Group 1	Group 2	Variable	*k*	*N*	δ	*SD*δ	80% CrI
Joined	Departed	Science & Technology	25	7,013	0.04	0.12	[-0.12, 0.19]
		Arts	25	7,013	0.07	0.14	[-0.11, 0.25]
		Social Service	25	7,013	0.02	0.00	[0.02, 0.02]
		Business Operations	25	7,013	-0.04	0.07	[-0.13, 0.06]
		Administration & Sales	25	7,013	-0.05	0.03	[-0.09, -0.02]
		Technical	25	7,013	-0.15	0.00	[-0.15, -0.15]
		People-Things	25	7,013	-0.11	0.00	[-0.11, -0.11]
		Data-Ideas	25	7,013	-0.09	0.16	[-0.29, 0.10]
Joined	Changed	Science & Technology	25	5,114	0.06	0.15	[-0.14, 0.26]
		Arts	25	5,114	0.08	0.13	[-0.09, 0.25]
		Social Service	25	5,114	-0.08	0.00	[-0.08, -0.08]
		Business Operations	25	5,114	-0.01	0.21	[-0.28, 0.26]
		Administration & Sales	25	5,114	-0.10	0.08	[-0.20, 0.01]
		Technical	25	5,114	-0.01	0.00	[-0.01, -0.01]
		People-Things	25	5,114	0.07	0.00	[0.07, 0.07]
		Data-Ideas	25	5,114	-0.11	0.10	[-0.24, 0.01]
Changed	Departed	Science & Technology	25	9,493	-0.06	0.09	[-0.17, 0.06]
		Arts	25	9,493	-0.03	0.00	[-0.03, -0.03]
		Social Service	25	9,493	0.08	0.00	[0.08, 0.08]
		Business Operations	25	9,493	-0.05	0.03	[-0.09, -0.02]
		Administration & Sales	25	9,493	0.02	0.00	[0.02, 0.02]
		Technical	25	9,493	-0.15	0.00	[-0.15, -0.15]
		People-Things	25	9,493	-0.17	0.00	[-0.17, -0.17]
		Data-Ideas	25	9,493	0.03	0.01	[0.02, 0.04]

Note. Bold indicates that the estimated mean effect size (δ) exceeds |0.20| and the credibility interval (CrI) does not contain zero. *k* = number of institutional studies; *SD*δ = standard deviation of estimated mean effect size; Departed = withdrew from institution; Changed = changed to another student major category (SMC); Joined = in another SMC in the first semester and later joined this SMC; Persisted = started in this SMC in the first semester and enrolled in the same SMC in the eighth semester.

Figure 2 contains the mean DI/PT score plots for the students who had been enrolled in one of the two STEM areas. As with the ACT scores and HSGPA, these four subcategories were based on the students' declared majors in the first and eighth semesters. While the plots for all eight groups are still in the lower right quadrant, the STEM-Biological majors who persisted were slightly higher on Ideas than were the students in any of the three other groups within the STEM-Biological SMC, and the persisting STEM-Quantitative majors were slightly higher on Things than were the other students within the STEM-Quantitative SMC. Note that for both STEM groups, the students who changed out of the STEM field had the greatest distance

from the students who had persisted in that field. Furthermore, while these differences may appear large in the chart, the effect sizes (Tables 5a, 5b, 6a, and 6b) were generally small in comparison to those found in ACT scores and HSGPA (Tables 3a, 3b, 4a, and 4b).

Figure 2. Data/Ideas and People/Things plots for STEM students' 8th semester status



Profiles of STEM Students: Persisters, Joiners, Changers, and Departers

The profiles of successful STEM majors in the first study included all STEM majors enrolled in the two STEM SMCs in the eighth semester. This study subdivides these successful STEM majors into two groups based on their declared major in the first and eighth semester: those who persisted in their STEM SMC from the first semester through the eighth semester, and those who started in another SMC in the first semester (or were undeclared – less than 2% in each STEM SMC) and then joined their STEM SMC by the eighth semester. This study also provides profiles of the non-persisting students who had declared a STEM major in the first semester—those who started in a STEM SMC but departed their institution before the eighth semester, and those who started in a STEM SMC but switched in another SMC after the first semester. The means and interquartile ranges for the ACT scores and HSGPAs of the STEM-Biological four groups are presented in Table 7. Table 8 contains the same information for the STEM-Quantitative majors. For the ACT scores and HSGPAs, the means in the tables generally rise going left to right, and in most cases there was a three-point difference between the mean scores for students who persisted in the STEM SMC and the mean scores for those who departed the institution. In contrast, the mean scores on the Interest Inventory and work task dimensions were not consistently higher for the persisters than those for the other groups.

Table 7: Persisting and Migrant STEM-Biological Majors' Interquartile Ranges for ACT Scores, HSGPAs, Interest Inventory Scores, and Calculated Work Task Dimension Scores

	Departed			Changed			Joined			Persisted		
Measure	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**
ACT Composite	20	23	25	21	24	26	22	25	28	23	26	28
ACT English	19	23	26	21	24	27	22	25	29	22	26	29
ACT Mathematics	18	22	25	20	23	26	22	25	28	23	26	28
ACT Reading	19	23	27	20	24	28	22	25	29	22	26	30
ACT Science	20	22	25	21	23	26	22	24	27	22	25	27
HSGPA	3.20	3.49	3.88	3.50	3.66	3.95	3.63	3.75	4.00	3.67	3.78	4.00
Science & Technology	53	59	65	54	59	63	54	59	65	55	61	66
Arts	44	51	57	45	51	57	45	51	57	45	51	58
Social Service	46	52	58	47	53	60	46	52	58	46	53	58
Administration & Sales	44	49	55	44	49	55	44	50	55	44	50	55
Business Operations	43	50	57	45	51	57	43	50	55	43	50	55
Technical	44	51	57	44	51	57	44	52	58	44	52	58
People-Things	-15	5	26	-19	1	20	-13	7	28	-13	7	27
Data-Ideas	-40	-17	3	-36	-17	3	-40	-18	3	-43	-22	-2

Table 8: Persisting and Migrant STEM-Quantitative Majors' Mean ACT Scores, HSGPAs, Interest Inventory Scores, and Calculated Work Task Dimension Scores

	Departed			Changed			Joined			Persisted		
Measure	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**
ACT Composite	21	24	27	22	25	28	22	25	28	24	27	30
ACT English	20	23	27	21	24	28	21	24	28	22	26	29
ACT Mathematics	21	25	28	22	25	28	23	26	29	25	28	31
ACT Reading	20	24	28	21	25	29	21	25	29	22	26	30
ACT Science	21	24	27	21	24	27	22	25	27	23	26	29
HSGPA	3.18	3.46	3.86	3.46	3.65	4.00	3.46	3.67	4.00	3.63	3.76	4.00
Science & Technology	50	56	62	50	56	62	51	57	62	52	57	62
Arts	45	51	57	45	51	57	46	52	58	45	51	57
Social Service	42	49	56	43	51	58	42	50	56	43	49	56
Administration & Sales	46	52	57	45	52	57	46	52	57	46	53	58
Business Operations	45	51	57	45	51	57	43	50	55	45	50	57
Technical	48	55	61	47	54	60	47	54	60	49	55	61
People-Things	-2	17	37	-9	11	32	-6	14	36	1	20	40
Data-Ideas	-29	-9	10	-29	-9	10	-33	-12	9	-29	-9	10

The means and interquartile ranges presented in Tables 7 and 8 were for all students across all institutions. However, as with the profiles provided in the first and second studies, the institutional means varied. Tables 9 and 10 contain the institutional median and interquartile ranges for the measures of their STEM majors' precollege academic achievement and interests. As in the previous two studies, the interquartile ranges for institutional means were narrower than the interquartile ranges for individual scores and HSGPAs, suggesting greater variation among students within institutions than across institutions.

Table 9: Institutional Median ACT Scores, HSGPAs, Interest Inventory Scores, and Calculated Work Task Dimension Scores for Persisting and Migrant STEM-Biological Majors

	Departed			Changed			Joined			Persisted		
Measure	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**
ACT Composite	21	23	24	22	23	24	23	24	26	23	24	26
ACT English	20	23	23	21	23	24	23	24	25	23	25	26
ACT Mathematics	20	22	23	21	22	24	23	24	26	22	24	26
ACT Reading	21	23	24	22	24	25	23	25	26	24	25	27
ACT Science	21	23	23	22	23	24	23	24	25	23	24	25
HSGPA	3.37	3.46	3.56	3.51	3.61	3.68	3.57	3.72	3.78	3.64	3.74	3.85
Science & Technology	57	59	61	56	58	60	57	58	61	59	61	62
Arts	50	51	52	49	51	52	49	51	53	50	52	52
Social Service	50	52	53	50	53	54	50	51	53	50	51	53
Administration & Sales	49	49	50	48	49	50	49	49	51	49	49	50
Business Operations	48	50	50	49	50	51	48	50	50	47	49	51
Technical	50	51	52	49	50	51	51	52	54	50	51	53
People-Things	3	7	12	-2	3	8	6	9	16	4	9	15
Data-Ideas	-25	-21	-12	-21	-17	-10	-23	-18	-15	-29	-25	-20

Table 10: Institutional Median ACT Scores, HSGPAs, Interest Inventory Scores, and Work Task Dimension Scores for Persisting and Migrant STEM-Quantitative Majors

	Departed			Changed			Joined			Persisted		
Measure	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**	**25th Percentile**	**Mean**	**75th Percentile**
ACT Composite	22	23	25	22	23	24	23	25	26	24	25	27
ACT English	21	21	24	22	22	24	22	23	25	23	24	26
ACT Mathematics	21	24	25	22	23	25	23	25	27	24	26	28
ACT Reading	21	23	25	22	23	25	22	24	26	23	24	26
ACT Science	22	23	25	22	24	24	23	24	26	24	25	26
HSGPA	3.25	3.35	3.51	3.46	3.57	3.67	3.54	3.66	3.75	3.58	3.73	3.76
Science & Technology	54	56	57	53	56	57	54	56	58	55	56	57
Arts	50	51	52	49	51	51	50	52	53	50	51	52
Social Service	48	49	50	48	50	51	48	48	51	47	48	50
Administration & Sales	51	52	52	50	51	53	50	51	53	52	53	54
Business Operations	49	50	51	49	51	51	47	50	52	47	49	51
Technical	53	54	56	52	54	55	51	53	54	53	55	56
People-Things	14	16	20	7	13	15	10	15	20	18	21	30
Data-Ideas	-12	-8	-5	-12	-7	-1	-18	-12	-6	-12	-9	-3

It is interesting to note that the mean ACT scores and HSGPAs for the departed STEM majors in this study were similar to those for the non-STEM majors who persisted through the eighth semester in the first study (Westrick, 2016, Table A1). Table 11 contains the profiles for the departed STEM Biological and STEM-Quantitative students from Tables 7 and 8, respectively, and the mean ACT scores and HSGPAs for the eighth semester non-STEM majors in the first study. The enrolled non-STEM majors differed from the departed STEM majors in their measured interests, especially on the Science & Technology and the Technical scales, and on the DI/PT dimensions.

Table 11: Mean ACT Scores and HSGPAs for STEM and Non-STEM Majors Based on Eighth Semester Enrollment Status

	Departed STEM-Biological	Departed STEM-Quantitative	Enrolled Non-STEM
Measure	**Mean**	**Mean**	**Mean**
ACT Composite	23	24	23
ACT English	23	23	24
ACT Mathematics	22	25	23
ACT Reading	23	24	24
ACT Science	22	24	23
HSGPA	3.49	3.46	3.56
Science & Technology	59	56	52
Arts	51	51	52
Social Service	52	49	52
Administration & Sales	49	52	50
Business Operations	50	51	53
Technical	51	55	50
People-Things	5	17	-6
Data-Ideas	-17	-9	-2

Discussion

The purposes of this study were twofold: one was to determine if there were differences of practical significance between students who persist in a STEM SMC and students who migrate into or out of a STEM SMC. Within both STEM SMCs, students enrolled as STEM majors in the eighth semester (persisters and joiners) tended to have higher levels of precollege academic achievement than did students who had left the STEM SMCs (changers and departers). This was especially true for ACT mathematics scores in the STEM-Quantitative analyses. On the other hand, the measured interests of the students within each STEM SMC were similar across all four groups, the exceptions being the differences found between persisters and changers in both STEM SMCs on the PT work-task dimension and the Science and Technology scale.

The comparisons made between the changers and the departers are important because the results may indicate why some students persist in college and others do not. On average, students in both groups had entered college with lower ACT scores and HSGPAs than did the students enrolled in STEM majors in the eighth semester of college. However, in both the STEM-Biological and STEM-Quantitative analyses, the changers had higher mean HSGPAs than the departers, and the differences were of practical significance. In fact, of the

comparisons made between departed students and students in the other three groups, HSGPA was the only measure where the standardized mean differences were always of practical significance. Other researchers have considered HSGPA to be a measure of academic achievement, non-cognitive, and behavioral characteristics (Noble & Sawyer, 2004; Sawyer, 2007; Willingham, Pollack, & Lewis, 2002). Perhaps the behavioral characteristics of the changers led to a stronger desire to earn a degree, be it in another STEM field or a non-STEM field, and, as their measured interests differed from those of the higher-performing STEM persisters, they were willing to move on from their original major to another field that better matched their abilities and interests.

The second purpose of this study was to provide profiles of the four classifications of students enrolled in a STEM SMC in the first and/or eighth semester. The profiles provide a quick snapshot of the measured characteristics of the students in each classification, much as institutions often provide profiles of their incoming first-year students. Within each STEM SMC, the general trend was for the students who persisted in the SMC from the first semester through the eighth semester to have the highest mean ACT test scores and HSGPAs. They were followed by the students who migrated into the STEM SMC after the first semester, followed by the students who changed from the STEM SMC to another SMC, and finally by the students who departed the institution before the eighth semester. As for measured interests, the differences between the means for the persisters, joiners, and departers were minimal within each SMC, though the differences between the mean PT scores for the persisters and the changers were more prominent.

Of the 24,663 students who had declared a major that was in either of two STEM SMCs in the first semester, 8,972 (36%) persisted, 6,394 changed to another SMC (26%), and 9,297 (38%) departed their initial institution of study before the eighth semester. Student retention is a common concern across postsecondary institutions, and institutions use a variety of approaches to retain their students. They may encourage struggling students to reevaluate their choice of major, and they may encourage their students to pursue studies in academic majors better aligned with the students' academic abilities and interests. However, the results of the current study indicated that the students who departed their STEM SMC had measured interests that were very similar to the measured interests of the students who had persisted in or joined the same STEM SMC. Where they differed from their peers was in their levels of precollege academic achievement. Many of the STEM students who departed may have realized that they were struggling in the major of their choice, but they also realized that they were not interested in other majors offered at their institutions despite having the academic ability to succeed in a variety of those majors. Research on interests and abilities suggests that what a person can do is not necessarily what a person will do (Lubinski & Benbow, 2007). This may apply to students whose interests align with a particular STEM field but enter college underprepared for the academic work required in that field, and then choose to leave the institution rather than change to another area of study.

Limitations and Future Research

Although the current study has provided insights on the differences between students' persistence in STEM fields or their migration into or out of STEM fields, there are questions that remain unanswered. One limitation of the current study was departed STEM students could not be tracked after they left their initial institution. This inability to track students after

they departed their initial institution made it impossible to determine if the students persisted as a STEM major or as a non-STEM major at another institution. As the departed students in this study had entered their initial institutions with lower levels of precollege academic achievement, they may have transferred to institutions that were a better match for their academic abilities. A study tracking STEM students across institutions using National Student Clearinghouse data could help researchers determine if these departed students were ultimately successful in earning a STEM degree.

Another limitation was the use of three SMCs rather than using individual majors. This series of studies used two STEM categories, STEM-Biological and STEM-Quantitative, for the analyses. This system had proven to be advantageous given that there was insufficient data on specific majors across multiple institutions. The classification system made it possible to demonstrate that the STEM majors differed from the non-STEM majors in important ways, and the system made it possible to demonstrate that there was a need for more than one STEM category, as there were differences of practical significance between the STEM-Biological and STEM-Quantitative majors. However, a drawback to collapsing a wide variety of STEM majors into two general categories was that it obscured the interest profiles of individual majors within each category (ACT, 1995, 2009). Nevertheless, the effect sizes seen for the comparisons between persisters and changers regarding their PT work task dimension scores suggest that the SMC system did not obfuscate important differences between the groups. Providing profiles of successful students within specific majors (e.g., chemical engineering) would be a tremendous step forward in providing insights to high school students and counselors.

Finally, modeling when students join or depart a STEM major is a subject for future research. This study focused on students declared major status in the first and eighth semesters, which led to the omission of data worthy of further analysis. Modeling the times when students join or depart a STEM major could provide insights for institutions seeking to boost the number of students in STEM majors through recruiting and retention programs.

Conclusions

Previous research has demonstrated that STEM students who entered college with higher ACT scores and HSGPAs and had interests aligned with those of other STEM majors were more likely to enroll in and/or persist in a STEM major (Allen & Robbins, 2010; Le, Robbins, & Westrick, 2014; Radunzel, et al., 2016). This study adds to the literature by providing descriptive profiles of persisting STEM majors and of students who migrated into or out of STEM majors. STEM students who dropped out, transferred to other institutions, or stayed at their institution but changed to another SMC had noticeably lower mean ACT scores and HSGPAs when compared to students enrolled as STEM majors in the eighth semester. Most differences were of practical significance, with the effect sizes for ACT mathematics comparisons standing out for both the STEM-Biological and STEM-Quantitative analyses. STEM students who departed their initial institution before the end of the fourth year entered college with lower mean HSGPAs than did students in the other groups, including those who left a STEM SMC but persisted in another SMC. Another important finding was that within both STEM SMCs, specifically the departed STEM majors did not differ much from the persisting STEM majors regarding their measured interests.

Student attrition in the STEM fields is well documented (e.g., Chen, 2009, 2013), and in this study more than 60 percent of the students who started as STEM majors changed majors or left school. Attempts to increase the number of students in the STEM pipeline by generating more student interest in STEM is a worthy endeavor. However, the results of this study suggest that students enrolled in a STEM major in the eighth semester have not only measured interest in STEM but they also have high levels of precollege academic achievement. Efforts to increase student interest in STEM should continue, but these efforts should be coupled with efforts to raise student awareness of the precollege academic achievement levels associated with persistence in STEM majors throughout college.

References

ACT. (1995). *Technical manual: Revised unisex edition of the ACT Interest Inventory (UNIACT)*. Iowa City, IA: ACT.

ACT. (2009). *The ACT Interest Inventory technical manual.* Iowa City, IA: ACT.

ACT. (2014). *The ACT technical manual*. Iowa City, IA: ACT.

Allen, J. & Robbins, S. B. (2010). Effects of interest-major congruence, motivation, and academic performance on timely degree attainment. *Journal of Counseling Psychology, 57*(1), 23–35.

Chen, X. (2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education* (NCES 2009-161). National Center for Education Statistics. Washington, DC: U. S. Department of Education.

Chen, X. (2013). *STEM attrition: College students' paths into and out of STEM fields* (NCES 2014-001). National Center for Education Statistics, Institute of Education Sciences. Washington, D.C.: U.S. Department of Education.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Government Accountability Office (GAO). (2012). *Science, technology, engineering, and mathematics education: Strategic planning needed to better manage overlapping programs across multiple agencies* (GAO-12-108). Washington, DC: GAO.

Holland, J. L. (1997). *Making vocational choices: A theory of vocational personalities and work environments*. (3rd ed.). Odessa, FL: Psychological Assessment Resources.

Le, H., Robbins, S., & Westrick, P. (2014). Predicting student enrollment and persistence in college STEM fields using an expanded P-E fit framework: A large-scale multilevel study. *Journal of Applied Psychology*, *99*(5), 915–47. Retrieved from http://dx.doi.org/10.1037/a00354998.

Lubinski, D., & Benbow C. P. (2007). Sex differences in personal attributes for the development of scientific expertise. In S. J. Ceci and W. M. Williams (Eds.), *Why aren't more women in science?: Top researchers debate the evidence,* (pp.79–100). Washington, DC: American Psychological Association.

Mattern, K. D., & Patterson, B. F. (2011). *Validity of the SAT for predicting fourth-year grades: 2006 SAT validity sample* (College Board Statistical Report 2011-7). New York, NY: The College Board.

National Center for Education Statistics. (2002). *Classification of instructional programs: 2000 edition* (NCES 2002–165). U.S. Department of Education, Office of Educational Research and Improvement. Washington, D.C.: U.S. Department of Education.

Noble, J. P., & Sawyer, R. L. (2004). Is high school GPA better than admission test scores for predicting academic success in college? *College and University, 79*(4), 17–22.

Radunzel, J., Mattern, K., Crouse, J., & Westrick, P. (2015). *Development and validation of a STEM benchmark based on the ACT STEM score*. Iowa City, IA: ACT.

Radunzel, J., Mattern, K., & Westrick, P. (2016). *The role of academic preparation and interest on STEM success*. Iowa City, IA: ACT.

Sawyer, R. (2007). Indicators of usefulness of test scores. *Applied Measurement in Education, 20*(3), 255–271.

Schmidt, F. L., & Hunter, J. E. (2015). *Methods of meta-analysis: Correcting error and bias in research findings* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Venkataraman, B., Riordan, D. G., & Olson, S. (2010). *Prepare and inspire: K–12 education in science, technology, engineering, and math (STEM) for America's future*. Washington, DC: President's Council of Advisors on Science and Technology.

Westrick, P. (2016). *Profiles of Persisting Fourth-Year STEM majors.* Iowa City, IA: ACT.

Westrick, P. (2017). *Profiles of more-successful STEM majors.* Iowa City, IA: ACT.

Westrick, P. A., Le, H., Robbins, S. B., Radunzel, J. M., & Schmidt, F. L. (2015). College performance and retention: A meta-analysis of the predictive validities of ACT® scores, high school grades, and SES. *Educational Assessment*, *20*(1), 23–45.

White House, Office of the Press Secretary. (2009). President Obama Launches "Educate to Innovate" Campaign for Excellence in Science, Technology, Engineering & Math (STEM) Education. Retrieved from http://web.archive.org/web/20160117041123/http://www.whitehouse.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en

Willingham, W. W., Pollack, J. M., & Lewis, C. (2002). Grades and test scores: Accounting for observed differences. *Journal of Educational Measurement, 39*(1), 1–37.

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