High School Science Fair: School Location Trends in Student Participation and Experience

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Abstract

The findings reported in this paper are based on surveys of U.S. high school students who registered and managed their science and engineering fair (SEF) projects through the online Scienteer website over the three years 2019/20, 2020/21, and 2021/22. Almost 2500 students completed surveys after finishing all their SEF competitions. Our findings confirmed and extended previous observations regarding differences in students' SEF experiences based on gender and ethnicity. In this paper we report results on high school location. Most students participating in SEFs indicated that they were from suburban schools with some variation depending upon student ethnicity -- Asian-81%, Black-68%, Hispanic-55%, and White-78%. Very few SEF participants -- 3.5% overall -- indicated that they were from rural schools, even though more than 20% of high school students attend rural schools. Urban vs. suburban school location appeared to have little impact on any of the students' SEF experiences. For instance, although Asian and Hispanic students indicated more successful SEF outcomes than Black and White students, Asian students were the most likely to attend suburban schools, whereas Hispanic students were relatively balanced in their attendance at suburban and urban schools. In those instances where we observed statistically significant ($p<.05$) differences in students' experiences based on school location, students from suburban schools were slightly favored in relationship to students from urban schools but the differences always were small. In conclusion, although most students participating in SEFs come from suburban schools, students participating in SEFs and coming from urban schools can have equivalent SEF experiences, and very few students participating in SEFs come from rural schools.

Introduction

In recent years, ideas about how best to accomplish science education have focused increasingly on hands-on science and engineering (S&E) practices [1-3]. Science and engineering fairs (SEFs) provide an ideal means for students to experience for themselves the practices of science and engineering described by Next Generation Science Standards (NGSS) [4, 5]. SEFs potentially can promote three important and desirable outcomes: (i) mastery of S&E practices, (ii) interest in science, and (iii) interest in science careers [6].

The number of U.S. high school students who participate in SEFs each year is not known exactly, but we estimate several hundred thousand. The 2009/12 NCE-HSLS report found that 5% of high school students participated in science competitions during high school [7],which would correspond to an upper limit of about 750,000 students given the overall U.S. public high school population of about 15 million [8] (does not include about ~10% of students attending private schools [9]). Similarly, about 5% of the almost 16,000 undergraduate students surveyed in the college Outreach Programs and Science Career Intentions survey (students in introductory freshman, mostly English, classes) reported participating in SEFs [10].

In our studies, we surveyed a national sample of high school students who use the Scienteer online portal (adopted by seven states) for SEF registration, parental consent, and project management. Almost 40,000 students/year registered using Scienteer for SEFs during the 2018/19 and 2019/20 school years [11]. Extrapolated to 50 states, the SEF student population by this calculation would be 225,000+.

The criticism sometimes has been made that SEFs are fundamentally unfair [12-14]. Factors contributing to SEF success include parental support and encouragement [15], social and research resources [16], and access to outside of school facilities [17]. Such advantages will not be available to all students. On the other hand, several studies suggest that innovative high school programs that combine student participation in SEFs with student and teacher support have the potential to promote STEM engagement and learning for all students and could be especially valuable for students from under-represented ethnic minorities and low socioeconomic backgrounds [18-22]. Consequently, whether or not SEFs might be able to achieve one of its two original goals -- fostering a better understanding of science for everyone [23] -- remains an open question.

Our research has utilized anonymous and voluntary surveys of U.S. regional and national student cohorts to learn about students' SEF experiences. Previously we studied what students indicated about help they received, obstacles encountered, and ways of overcoming obstacles. Also, we learned students' views about the value of requiring SEF participation including whether participation increased their interests in S&E [24, 25]. In a recent study on ethnicity trends in SEF participation and experience, we reported that Asian and Hispanic students had more successful SEF outcomes than Black and White students, and that Black students were least likely to receive help from scientists or coaching for the interview, two of the more important factors that correlate with successful SEF outcomes [11].

Since economic resources influence educational opportunities and outcomes [26, 27] and can be reflected in disparities between urban, suburban, and rural school districts [28], students' experiences and SEF outcomes might have differed depending on school location. To evaluate this possibility, beginning in 2019/20 we asked students participating in our surveys their *Location of high school* with the possible answers, *urban, suburban, or rural*.

In this paper, we report findings based on three years of surveys -- 2019/20, 2020/21, and 2021/22 -- that included the question regarding school location. We learned that most students were from suburban schools -- Asian (81%), Black (68%), Hispanic (55%), and White (78%). Very few SEF participants (3.5% overall) indicated that they were from rural schools. We confirm previous findings regarding differences in students' SEF experiences based on ethnicity and gender but observed little impact of school location on SEF outcomes between students from suburban vs. urban schools. In those instances where we observed statistically significant differences ($p<.05$), students from suburban schools were almost always favored in relationship to urban schools, but the percentage of students involved was small. Details are reported herein.

Materials and methods

This study was approved by the UT Southwestern Medical Center IRB (#STU 072014-076). Study design entailed administering to students a voluntary and anonymous online survey using the REDCap survey and data management tool [29]. Survey recipients were U.S. high school students who participated in SEFs during the 2019/20, 2020/21, and 2021/22 school years using Scienteer (www.scienteer.com) for online SEF registration, parental consent, and project management. Although we treat the Scienteer SEF population as a national group of U.S. high school students, it should be recognized that these students come from only 7 U.S. states: Alabama, Louisiana, Maine, Missouri, Texas, Vermont, and Virginia.

After giving consent for their students to participate in SEFs, parents could consent for their students to take part in the SEF survey. However, to prevent any misunderstanding by parents or students about a possible impact of agreeing to participate or actually participating in the survey, access to the surveys was not available to students until after they finished all of their SEF competitions. When they initially registered for SEF, students whose parents gave permission were told to log back in to Scienteer after completing the final SEF competition in which they participated. Those who did were presented with a hyperlink to the SEF survey. Scienteer does not send out reminder emails, and no incentives were offered for remembering to sign back in and participate in the survey.

Since 2016, Scienteer has recorded 135,000 parental consents, and more than 4,000 students have completed surveys, an overall response rate of about 3%. Given that student participation in the surveys involves an indirect, single electronic invitation without incentive or follow-up, this level of response would be expected [30-32].

Survey content was the same as that used previously[11]. Beginning in 2019, we included a question about the location of the student's high school (urban, suburban, rural). The survey can be found in supporting information (S1 Survey).

Survey data were summarized with frequency counts and percentages. Significance of potential relationships between data items was assessed using Chi-square contingency tables for independent groups. Results are presented both graphically to make overall trends easier to appreciate and in tables to show the actual numbers. A probability value of 0.05 or smaller was accepted as statistically significant but actual p values are shown. No adjustments were made for multiple comparisons.

Results

Overview of survey responses

Table 1 shows Scienteer registration numbers and ethnicity trends for the three years covered by this report. In 2019/20 and 2021/22 almost 40,000 students registered each year for SEFs. About 50% fewer students registered in 2020/21, perhaps a consequence of the COVID pandemic. Although the number of student registrations decreased markedly during 2020/21, year to year student ethnicity distribution was similar over all three years for Asian, Black, and White students. The number of Hispanic students appeared to decline.

In relationship to U.S. high school data (last row of Table 1) [33], obvious differences in ethnicity between Scienteer registration students and the overall U.S. student population were overrepresentation of Asian students and underrepresentation of Black, Hispanic and White students.

Table 1. Scienteer Registration and Ethnicity

Data Set	All Students	Asian	Black	Hispanic	White	Other*
	survey year	% of students				
	# of students					
Scienteer SEF registration	2019/20	14.6	6.6	24.5	26.1	28.1
	38570	5365	2504	9207	10010	11484
	2020/21	15.7	5.7	15.3	24.3	39.0
	23646	3720	1345	3619	5746	9216
	2021/22	12.5	6.2	17.6	23.6	40.1
	39148	4908	2409	6875	9246	15710
	Totals – 3 yrs	14.3	6.1	19.1	24.7	35.7
	101364	13993	6258	19701	25002	36410
US High School**	2019/20	5.5	14.7	27.0	48.0	4.8
	15227541	838619	2231971	4106253	7314416	736282

*Includes American Indian; Hawaiian Native/Pacific Islander; various mixed-race combinations; and students who choose not to answer. **from NCES Table 216.60 [33]

Most of the surveys submitted by students (83%) were complete and non-duplicates. In the completed surveys, students answered almost all the questions (>96%) except the question about level of SEF competition, which was less, about 80%. The completed surveys were used for data analyses, and year by year datasets can be found in Supporting Information (S1 Datasets). Consistent with Scienteer registration (Table 1), about 50% fewer students completed surveys in 2020/21.

Fig 1 shows year-by-year student demographic trends -- SEF participation grade, school location, gender, and ethnicity. Results for all three years were similar. Supplemental Table 1 (S1 Table) shows similarity of the entire year-by-year results for 100+ possible survey questions and answers regarding student demographics, opinions about SEF, help received, obstacles encountered, and ways of overcoming obstacles. For subsequent analyses, the 2019/20, 2020/21 and 2021/22 student survey results were combined.

Fig 1. Student survey demographics – year-to-year similarity

School Location and Student Ethnicity

Fig 2 shows survey trends for student ethnicity and school location. Ethnicity findings for Scienteer students who completed surveys followed a similar pattern overall compared to those who had registered with Scienteer except the category of students who selected “Other” was less than 5% rather than over 30%. In corresponding fashion, the percentages of Asian, Black and White students were higher. Compared to national student enrollment (Table 1), Asian students participating in SEFs were overrepresented almost 6-fold, whereas Black, Hispanic, and White students were underrepresented by about one third.

About 75% of the students overall indicated that they were from suburban schools.

Representation of students from urban schools was higher for Black and Hispanic students than Asian and White students. The suburban to urban ratios were 4:1 for Asian and White students, 2.5:1 for Black students, and 1.4:1 for Hispanic students. Less than 5% of the students indicated that they were from rural schools, which contrasts sharply with student attendance at rural school that ranges from 7% of Asian students to 28% of White students [33].

Fig 2. Student ethnicity and school location

School Location, Student Experience and SEF Outcomes

Fig 3 presents results regarding students' experiences and SEF outcomes in relationship to school location. In this and subsequent figures we only compare students from suburban vs. urban schools because so few students were from rural schools.

Similar to our previously reported findings[11, 24], 60-70% of students who participated in SEFs were required to do so. About half the students received help from parents and or teachers. Less than 10% received help from scientists. More than half the students reported using internet resources, always the most frequently used resource for help. Compared to students from urban schools, those from suburban schools were slightly less likely to be required to participate in SEFs and indicated slightly more parental help and more use of the internet and books and magazines.

Three survey questions that we ask focus on SEF outcomes: (i) level of SEF competition reached by the students; (ii) whether SEF participation increased student interest in S&E; and (iii) whether students were interested in a S&E career. No differences were observed between students from suburban vs. urban schools in level of SEF competition or whether students indicated that participating in SEFs increased their interests in S&E. However, students from suburban schools were more likely than students from urban schools to indicate an interest in a career in the sciences or engineering.

The results in Fig 3 reflect a common trend we observed throughout the findings presented in this report. Differences in SEF experiences, if they were observed, almost always favored students from suburban schools. However, although these differences were significant statistically, i.e., $p<.05$, they always were small in relationship to the percentage of students involved.

Fig 3. School location and SEF help and outcomes

School Location, Ethnicity and SEF Experience

Previously, we described significant differences in SEF experiences according to student ethnicity [11]. Fig 4, now based on two additional survey years and twice as many students, confirms and extends the previous findings. Asian and Hispanic students had more successful SEF experiences than Black and White students according to level of competition reached and on whether students indicated that SEF participation increased their interests in S&E. White students were more likely than others to get help from parents and help fine tuning their SEF reports. Black students were least likely to get help from scientists and to receive coaching for the interview. Asian students were more likely than others to get help from scientists and to be interested in a career in the sciences or engineering.

Fig 4. Ethnicity and SEF experience

Fig 5 reorders the data from Fig 4 to compare student ethnicity and experience according to school location. Numerical and statistical details for the figure can be found organized by ethnic group in supplemental data (S2 Table). Asterisks in Fig 5 = $p<.05$, S2 Table. Few differences were evident that correlated with school location. Asian students from suburban schools were more likely than Asian students from urban schools to advance to SEFs beyond the school level and more likely to indicate an interest in a career in the sciences or engineering. Hispanic students from suburban schools were more likely to get help fine tuning their reports. White students from urban schools were more likely to get help from scientists.

Fig 5. School location, ethnicity, and SEF experience

School Location, Gender and SEF Experience

Fig 6 shows survey trends for student gender, location, and ethnicity. A majority of students who completed surveys were female (1.37:1). That ratio was slightly lower for suburban schools (1.28:1) and higher for urban schools (1.69:1). In relationship to ethnicity, the ratio of females to male students completing surveys for Hispanic and White students was about the same as overall. However, for Asian students, the ratio was almost even (1.10:1), whereas for Black students, females far outnumbered males (2.47:1).

Fig 6. Gender, school location and ethnicity

In an earlier study, we reported no gender-based differences in student SEF experiences [34], but that was with a much smaller dataset and before we included questions about level of SEF competition, impact of SEF participation, and interest in a S&E career. Fig 7 shows that males and female students received a similar degree of help from parents and teachers and achieved similar outcomes in the level of SEF competitions in which the students participated. However, males were somewhat more likely to receive help from scientists, more likely to indicate that SEFs increased their interests in S&E, and more likely to be interested in a S&E career.

Fig 7. Gender and SEF experience

Fig 8 reorders the data from Fig 7 to compare student experience according to gender and school location. Numerical and statistical details for the figure can be found organized by ethnic group in supplemental data (S3 Table). Asterisks in Fig 8 = $p<.05$, S3 Table. Other than males from suburban schools receiving slightly more help from parents compared to students from urban schools, no effect of school location was evident.

Fig 8. School location, gender, and SEF experience

Discussion

In this paper, we report location trends in U.S. student participation in high school science

and engineering fairs in relationship to student experiences and SEF outcomes. Beginning in 2019/20, we added a question to our Scienteer SEF surveys to ask students their *Location of high school?* with the possible answers, *urban, suburban, or rural*. The findings reported in this paper are based on surveys of students who registered and managed SEF projects through the Scienteer website over the three school years 2019/20, 2020/21, 2021/22, more than 100,000 students, of whom almost 2500 completed surveys after finishing all of their SEF competitions. We treat the Scienteer SEF population as a national group. However, it should be recognized that these students may not be truly representative of a national sample since they come from only 7 U.S. states, and they only attend high schools where SEFs are available.

During 2020/21, we observed about a 50% decrease in students who signed up for SEFs using Scienteer and who filled out surveys after completing all of their SEF activities. The 50% decrease could have been a result of COVID. Notwithstanding the decrease in numbers of students who participated in SEFs, based on their survey answers, the experiences of those students who did participate were very similar year-to-year.

Overall student ethnicity trends confirmed previous findings [11]. Asian students were overrepresented in SEF participation compared to the U.S. school population; Black, Hispanic, and White students were underrepresented. Adding the new location data, we learned that the majority of the SEF students indicated that they came from suburban schools – Asian-81%, Black-68%, Hispanic-55%, and White-78%. Only 3.5% of the students -- 84 out of 2419 – indicated that they came from rural schools.

Education research typically uses urban, suburban, and rural designations to describe learning environments [35], whereas the U.S. Department of Education uses more nuanced definitions including the category *town* as a location distinct from *city*, *suburban*, and *rural*. According to these distinctions, 80-90% of Asian, Black and Hispanic students attend city and suburban schools with the percentage of Black and Hispanic students slightly higher in city schools and Asian students slightly higher in suburban schools. On the other hand, less than 60% of White students attend city and suburban schools with the remainder in schools designated Town-14% and Rural-28% schools [36].

The distribution of Hispanic students participating in SEFs was most like their U.S. school distribution pattern. The group with the biggest difference was White students since only 4% of the White SEF participants indicated that they were from rural schools, whereas 28% attend rural schools [33]. The underrepresentation of White students in our SEF surveys generally (Figure 1) compared to the US high school population (Table 1) could be explained in part by the fact that they are overrepresented in rural schools [39].

The low number of students completing our surveys from rural schools might occur if rural schools were not using Scienteer to register for SEFs. For students from a rural school to compete in a regional fair likely will not be possible without travel and overnight accommodations and the associated costs. So even if there is a rural school or district fair, the school might not consider entering students in a regional competition and therefore does not need to use Scienteer.

Alternatively, schools in rural communities might be less likely to have SEF participation available to students, similar to other decreased STEM opportunities that have been reported and attributed to a combination of smaller community size and fewer economic resources [28, 37]. The

2018 NSSME+ report showed that only 46% of high schools nationally participated in SEFs, and that smaller schools were half as likely than larger schools to offer such programs [38]. Organizing a SEF competition requires a critical mass to make the effort worthwhile. At a rural school with small enrolment, it may not be cost effective for the administration or time-effective for the teachers to organize a SEF. In addition, finding qualified judges might also be difficult if fewer S&T companies or higher education institutions are located nearby.

Although more students from suburban schools participated in SEFs compared to students from urban schools, overall student experiences and outcomes were very similar. No differences were observed regarding level of SEF competition and whether SEF participation increased a student's interest in S&E. Small statistically significant differences ($p<.05$) were observed regarding SEF requirements; help from parents, internet, and books and magazines; and interests in a career in S&E. However, the latter differences all involved only small percentages of students. We also observed minimal differences comparing school location outcomes in relationship to student ethnicity and gender.

Our findings run contrary to the common narrative of disparity in student performance between urban and suburban settings [28]. However, we cannot exclude the possibility that the students from urban schools in our surveys are just as successful in SEFs as those in the suburbs because of particularly supportive urban neighborhoods or school types (private, charter, parochial, etc.). This will be a topic for future investigation.

In conclusion, our survey findings show that most students participating in SEFs indicated that they were from suburban schools and very few were from rural schools. We confirmed and extended previous observations regarding differences in students' SEF experiences based on ethnicity and gender. School location appeared to have little impact on any of the students' SEF experiences. Although Asian and Hispanic students indicated more successful SEF outcomes than Black and White students, Asian students were the most likely to attend suburban schools, whereas Hispanic students were more balanced in their attendance at suburban and urban schools. In those instances where we observed statistically significant ($p<.05$) differences in students' experiences based on school location, students from suburban schools were slightly favored in relationship to students from urban schools but the differences always were small.

At their outset, one of the broad goals of SEFs was fostering a better understanding of science for everyone [23]. That students participating in SEFs from U.S. urban and suburban schools can have equivalent SEF experiences supports the possibility of using SEFs to achieve that broad goal. Why very few students from rural schools participated in our studies of SEF experience remains a question for the future.

Acknowledgments

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Supporting information

S1 Data set. Excel dataset showing all of the survey questions and answers.

S1 Survey. Survey questions.

S1 Table. Comparison of year-to-year survey responses.

S2 Table. School location, ethnicity, and students' SEF experiences.

S3 Table. School location, gender, and students' SEF experiences.

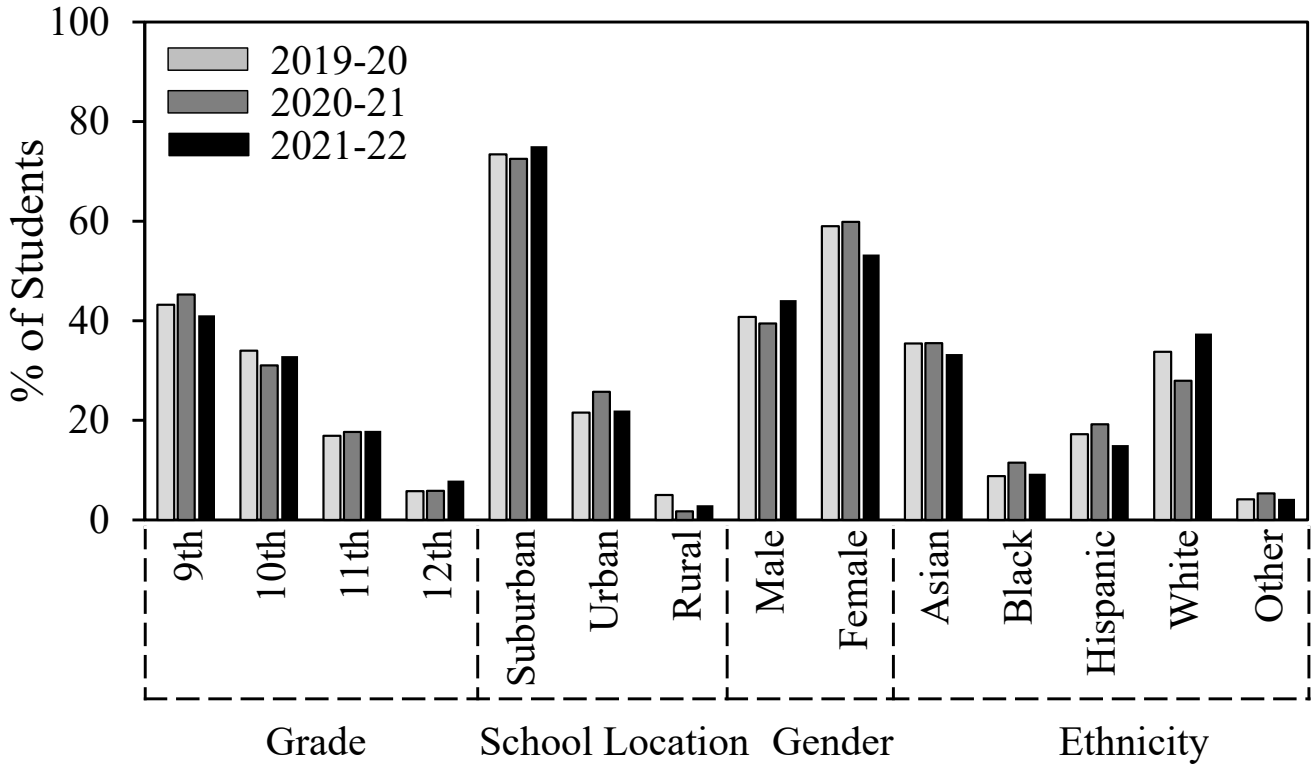
References Cited

1. Furtak EM, Penuel WR. Coming to terms: Addressing the persistence of "hands-on" and other reform terminology in the era of science as practice. Science education. 2019;103(1):167-86.
2. Lederman NG. Contextualizing the relationship between nature of scientific knowledge and scientific inquiry. Science & Education. 2019;`(3):249-67.
3. Osborne J. Teaching scientific practices: Meeting the challenge of change. Journal of Science Teacher Education. 2014;25(2):177-96.
4. National Research Council. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, D.C.: National Academies Press; 2012.
5. NGSS Lead States. Next Generation Science Standards For States, By States. Volume 1: The Standards—Arranged by Disciplinary Core Ideas and by Topics. Washington, D.C.: National Academies Press; 2013.
6. Kook JF, DeLisi J, Fields ET, Levy AJ. Approaches for conducting middle school science fairs: a landscape study. Science Educator. 2020;27(2):71-80.
7. U.S. Department of Education National Center for Education Statistics. X2RACE from High School Longitudinal Study of 2009 (HSLS:09) First Follow-up 2013. Available from: https://nces.ed.gov/pubs2014/2014360.pdf.
8. National Academies of Sciences E, and Medicine. Science and engineering for grades 6-12: Investigation and design at the center: National Academies Press; 2019.
9. U.S. Department of Education National Center for Education Statistics. Private Elementary/Secondary School Universe Survey," 2019-20 2021. Available from: https://nces.ed.gov/programs/digest/d21/tables/dt21_205.10.asp.
10. Miller K, Sonnert G, Sadler P. The influence of students' participation in STEM competitions on their interest in STEM careers. International Journal of Science Education, Part B. 2018;8(2):95-114.
11. Grinnell F, Dalley S, Reisch J. High school science fair: Ethnicity trends in student participation and experience. PloS one. 2022;17(3):e0264861.
12. Craven J, Hogan T. Rethinking the science fair. Phi Delta Kappan. 2008;89(9):679.
13. Flanagan J. Science fairs: rewarding talent or privilege? PLOS Blogs Sci-Ed. 2013;*blogs.plos.org/scied/2013/04/15/science-fairs-rewarding-talent-or-privilege/*.
14. Schank H. Science Fairs Aren't So Fair. The Atlantic. 2015;Mar 12, 2015
15. Czerniak CM, Lumpe AT. Predictors of science fair participation using the theory of planned behavior. School Science and Mathematics. 1996;96(7):355-61.

16. Bencze JL, Bowen GM. A national science fair: Exhibiting support for the knowledge economy. International Journal of Science Education. 2009;31(18):2459-83.
17. Gifford VD, Wiygul SM. The effect of the use of outside facilities and resources on success in secondary school science fairs. School Science and Mathematics. 1992;92(3):116-9.
18. Mernoff B, Aldous AR, Wasio NA, Kritzer JA, Sykes ECH, O'Hagan K. A Reverse Science Fair that Connects High School Students with University Researchers. Journal of Chemical Education. 2017;94(2):171-6.
19. Lakin JM, Ewald ML, Hardy EE, Cobine PA, Marino JG, Landers AL, et al. Getting Everyone to the Fair: Supporting Teachers in Broadening Participation in Science and Engineering Fairs. Journal of Science Education and Technology. 2021:1-20.
20. Koomen MH, Hedenstrom MN, Moran MK. Rubbing elbows with them: Building capacity in STEM through science and engineering fairs. Science Education. 2021;105(3):541-79.
21. Stray S, Gordy X, Sullivan D, Bender S, Cook C, McKone K, et al. Base Pair: 28 years of Sustained High School Biomedical Research Mentorship Driving Health Sciences Career Progression. Journal of STEM Outreach. 2020;3(3):1-10.
22. Todd C. Collaborations between Under-Resourced High School Students and STEM Professionals to Increase Participation in Science and Engineering Fairs. European Journal of Education and Pedagogy. 2022;3(1):1-6.
23. The New York Times. Plans Science Club for School Pupils. May 22 1932.
24. Grinnell F, Dalley S, Reisch J. High school science fair: Positive and negative outcomes. PLOS ONE. 2020;15(2):e0229237.
25. Grinnell F, Dalley S, Shepherd K, Reisch J. High school science fair: Student opinions regarding whether participation should be required or optional and why. PLOS ONE. 2018;13(8):e0202320.
26. Owens A. Income segregation between school districts and inequality in students' achievement. Sociology of Education. 2018;91(1):1-27.
27. Rauscher E, Shen Y. Variation in the Relationship between School Spending and Achievement: Progressive Spending Is Efficient. American Journal of Sociology. 2022;128(1):189-223.
28. Logan JR, Burdick-Will J. School segregation and disparities in urban, suburban, and rural areas. Annals of the American Academy of Political and Social Science. 2017;674(1):199-216.
29. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. Journal of biomedical informatics. 2009;42(2):377-81.
30. Kent R, Brandal H. Improving email response in a permission marketing context. International Journal of Market Research. 2003;45(4):1-13.
31. Van Mol C. Improving web survey efficiency: the impact of an extra reminder and reminder content on web survey response. International Journal of Social Research Methodology. 2017;20(4):317-27.
32. Shih T-H, Fan X. Comparing response rates from web and mail surveys: A meta-analysis. Field methods. 2008;20(3):249-71.
33. U.S. Department of Education National Center for Education Statistics. Public Elementary/Secondary School Universe Survey," 2019-20 2021. Available from: https://nces.ed.gov/programs/digest/d21/tables/dt21_216.60.asp.
34. Grinnell F, Dalley S, Shepherd K, Reisch J. High school science fair and research integrity. PLOS ONE. 2017;12(3):e0174252.
35. Bradley F, Feldman A. The problematic use of urban, suburban, and rural in science education. Cultural Studies of Science Education. 2021;16(4):1289-313.

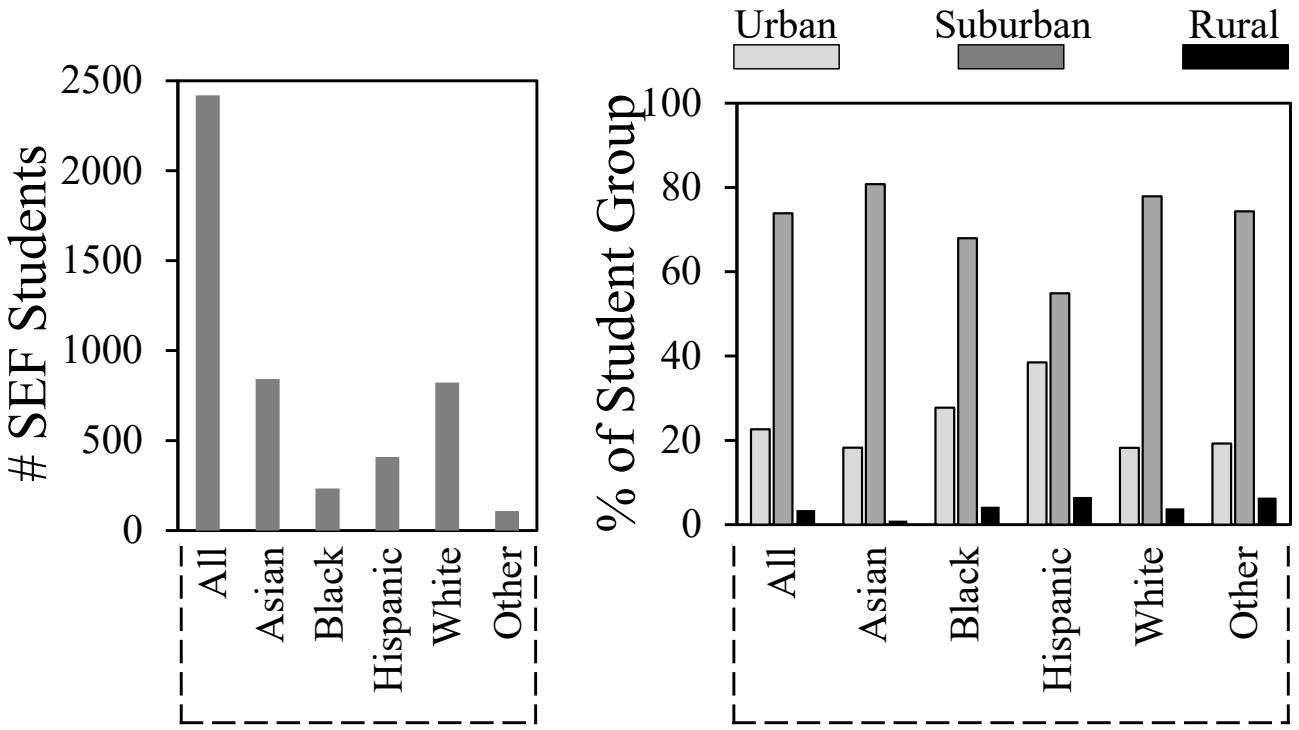
36. U.S. Department of Education National Center for Education Statistics. School Locale Definitions 2006. Available from: https://nces.ed.gov/surveys/urbaned/definitions.asp.
37. Saw GK, Agger CA. STEM pathways of rural and small-town students: Opportunities to learn, aspirations, preparation, and college enrollment. Educational Researcher. 2021;50(9):595-606.
38. Banilower ER, Smith PS, Malzahn KA, Plumley CL, Gordon EM, Hayes ML. Report of the 2018 NSSME+. Horizon Research, Inc. 2018.

Figure 1. Student survey demographics -- year to year similarity



Questions	Answers	Survey Year (# students)		
		2019-20 (900)	2020-21 (583)	2021-22 (951)
		% (#)		
What grade are you in?	9th	43.2 (389)	45.3 (264)	41.1 (391)
	10th	34.0 (306)	31.0 (181)	32.9 (313)
	11th	16.9 (152)	17.7 (103)	17.9 (170)
	12th	5.8 (52)	5.8 (34)	7.9 (75)
Location of high school?	Suburban	73.4 (661)	72.6 (423)	75.1 (714)
	Urban	21.6 (194)	25.7 (150)	22.0 (209)
	Rural	5.0 (45)	1.7 (10)	2.9 (28)
Gender?	Male	40.8 (367)	39.5 (230)	44.2 (420)
	Female	59.0 (531)	59.9 (349)	53.3 (507)
Ethnicity most identified with?	Asian	35.4 (319)	35.5 (207)	33.3 (317)
	Black	8.8 (79)	11.5 (67)	9.3 (88)
	Hispanic	17.2 (155)	19.2 (112)	15.0 (143)
	White	33.8 (304)	28.0 (163)	37.4 (356)
	Other	4.1 (37)	5.3 (31)	4.2 (40)

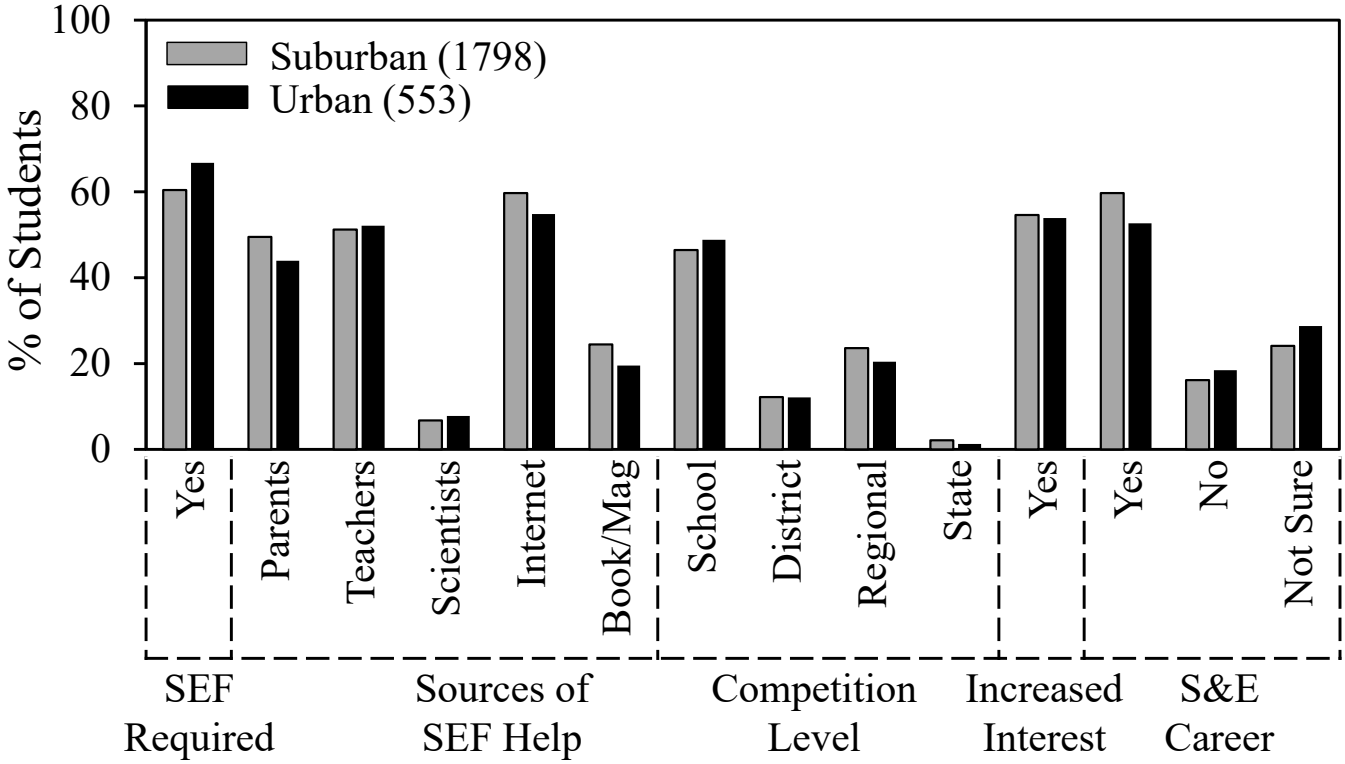
Figure 2. Student ethnicity and school location



SEF Survey Students % (#)		Distribution by School Locations		
		Urban % (#)	Suburban % (#)	Rural % (#)
All	100 (2419)	22.7 (548)	73.9 (1787)	3.5 (84)
Asian	34.8 (843)	18.3 (154)	80.8 (681)	0.9 (8)
Black	9.7 (234)	27.8 (65)	67.9 (159)	4.3 (10)
Hispanic	16.9 (410)	38.5 (158)	54.9 (225)	6.6 (27)
White	34.0 (823)	18.2 (150)	77.9 (641)	3.9 (32)
Other*	4.5 (109)	19.3 (21)	74.3 (81)	6.4 (7)

*Other = American Indian/Alaskan Native, 8; Native Hawaiian or Other Pacific Islander, 8; Mixed, 93

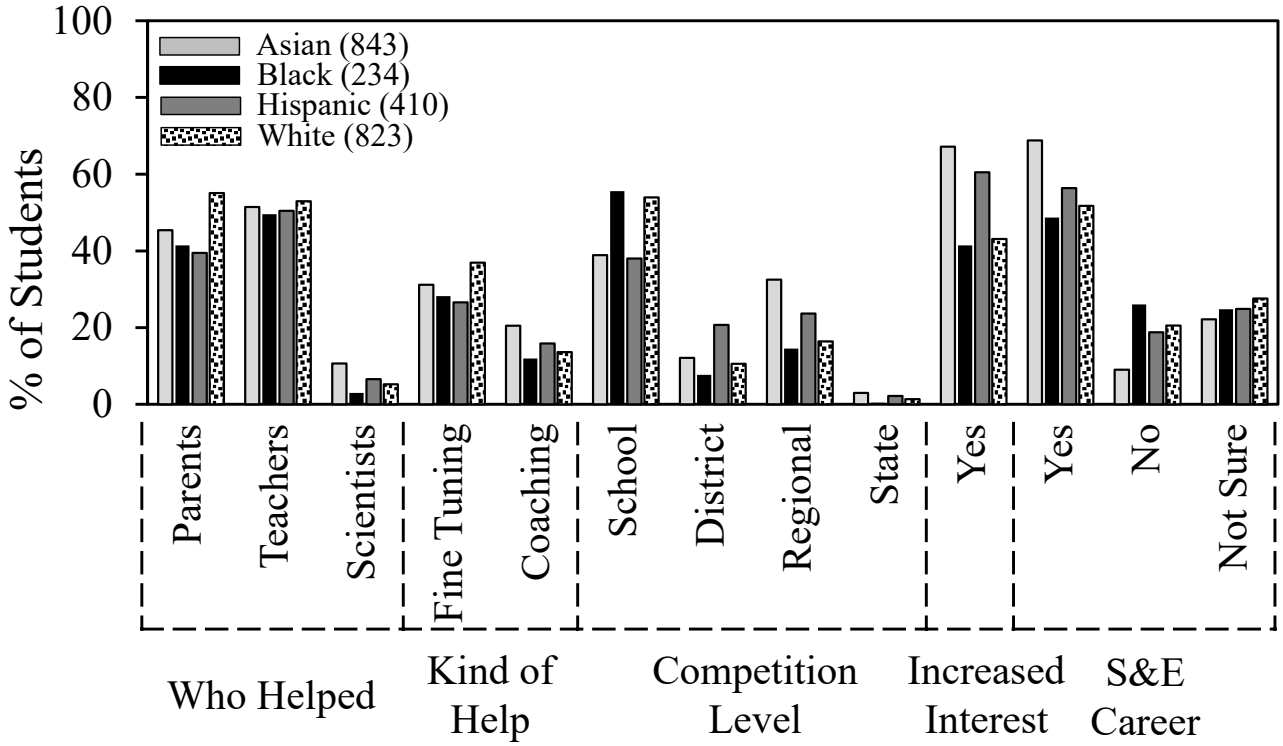
Figure 3. School location and SEF outcomes



Survey Questions	Answers	Student School Location (# Students)		p Value
		Suburban (1798)	Urban (553)	
		Student Answers % (#)		
SEF Required?	Yes	60.4 1086	66.7 369	.007
SEF help? (inclusive)	Parents	49.5 (890)	43.9 (243)	.022
	Teachers	51.2 (920)	52.1 (288)	.708
	Scientists	6.7 (121)	7.8 (43)	.398
	Internet	59.7 (1073)	54.8 (303)	.041
	Book/Magazines	24.5 (440)	19.5 (108)	.016
Highest level of SEF competition?*	School	46.4 (835)	48.8 (270)	.279
	District	12.2 (219)	12.1 (67)	
	Regional	23.6 (424)	20.4 (113)	
	State	2.1 (38)	1.3 (7)	
SEF participation increased your interest in S&E?	Yes	54.6 (981)	53.9 (298)	.782
Interest in a career in the sciences or engineering?	Yes	59.7 (1073)	52.6 (291)	.014
	No	16.1 (290)	18.4 (102)	
	Not sure	24.1 (434)	28.8 (159)	

*Answer completion rate >96.5% except for the question about level of SEF competition, which averaged 83%.

Figure 4. Ethnicity and SEF experience



Survey Questions	Answers	Ethnicity				p Value
		Asian % (#)	Black % (#)	Hispanic % (#)	White % (#)	
Who helped you with your SEF project? (inclusive)	Parents	45.4 (383)	41.5 (97)	39.5 (162)	55.0 (453)	<.001
	Teachers	51.5 (434)	49.6 (116)	50.5 (207)	53.0 (436)	0.749
	Scientists	10.7 (90)	3.0 (7)	6.6 (27)	5.2 (43)	<.001
Kind of help received	Fine tuning report	31.2 (263)	28.2 (66)	26.6 (109)	36.9 (304)	<.001
	Coaching Interview	20.5 (173)	12.0 (28)	15.9 (65)	13.6 (112)	<.001
Highest level of SEF competition?*	School	38.9 (328)	55.6 (130)	38.0 (156)	53.9 (444)	<.001
	District	12.1 (102)	7.7 (18)	20.7 (85)	10.6 (87)	
	Regional	32.5 (274)	14.5 (34)	23.7 (97)	16.4 (135)	
	State	3.0 (25)	0.4 (1)	2.2 (9)	1.3 (11)	
SEF increased interest in S&E?	Yes	67.1 (566)	41.5 (97)	60.5 (248)	43.1 (355)	<.001
Interest in S&E Career	Yes	68.8 (580)	48.7 (114)	56.3 (231)	51.8 (426)	<.001
	No	9.0 (76)	26.1 (61)	18.8 (77)	20.5 (169)	
	Not Sure	22.2 (187)	24.8 (58)	24.9 (102)	27.6 (227)	

*Answer completion rate >96.5% except for the question about level of SEF competition, which averaged 83%.

Figure 5. School location, ethnicity, and SEF experience

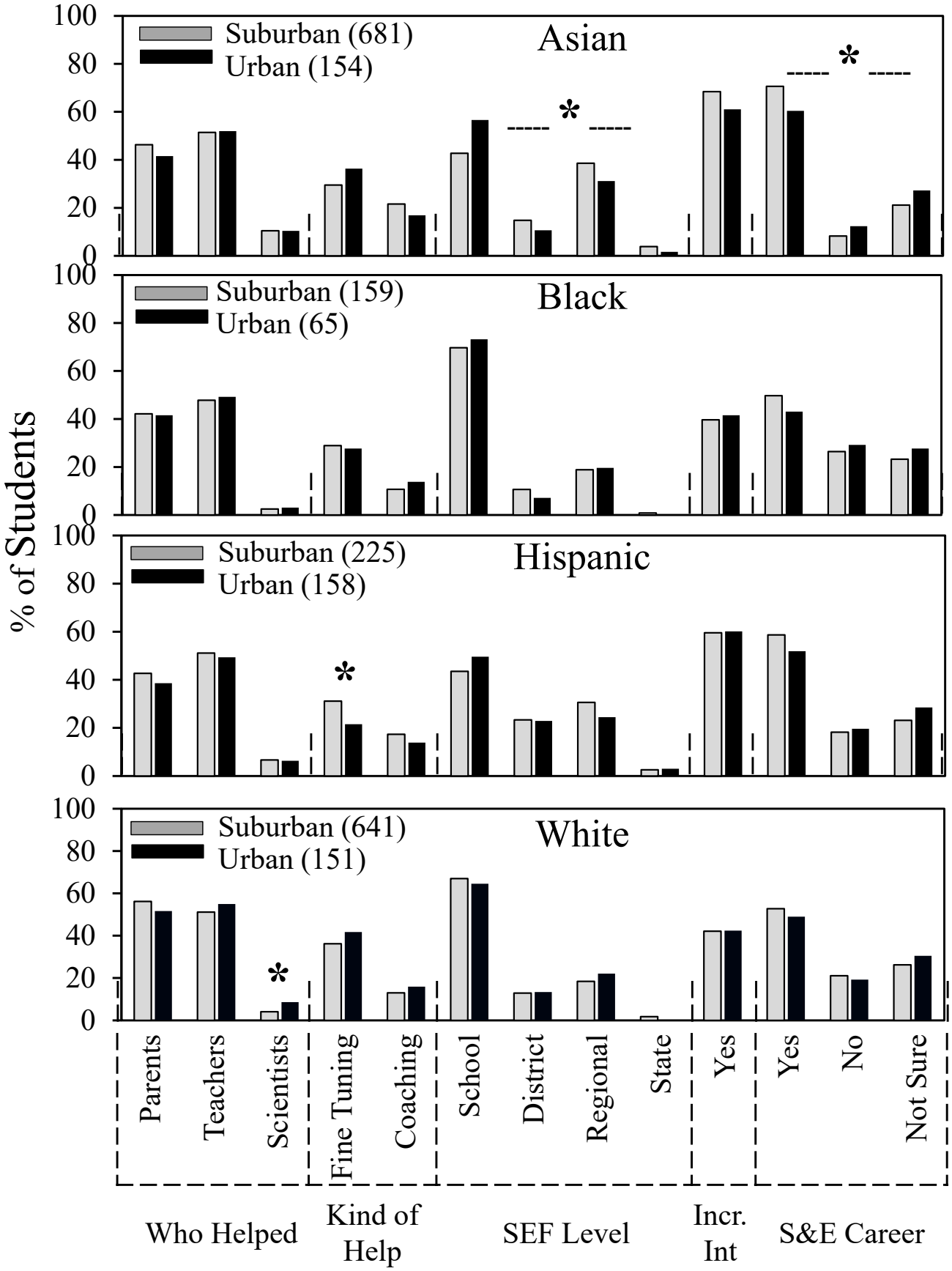
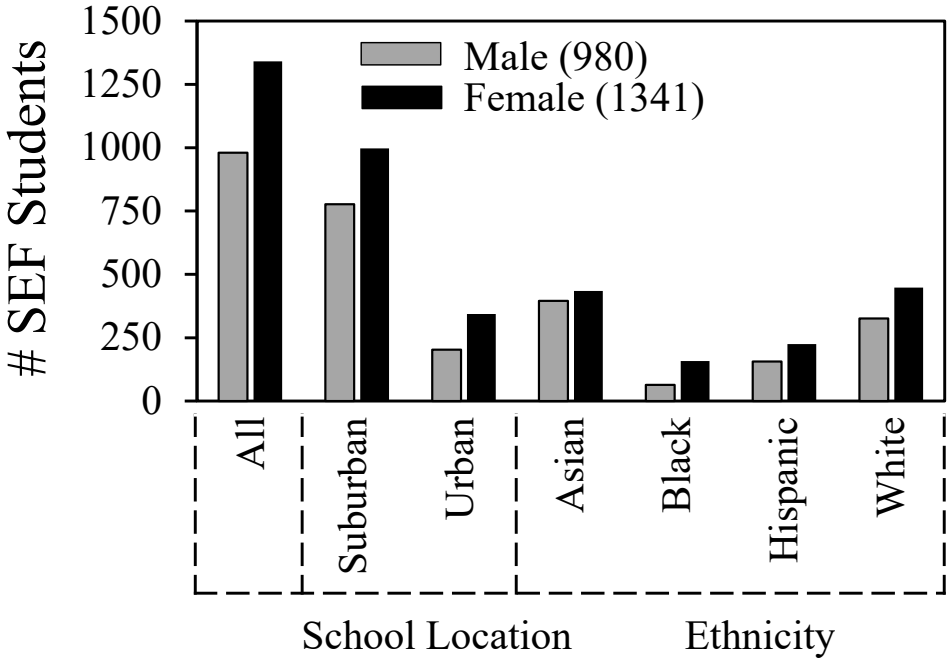
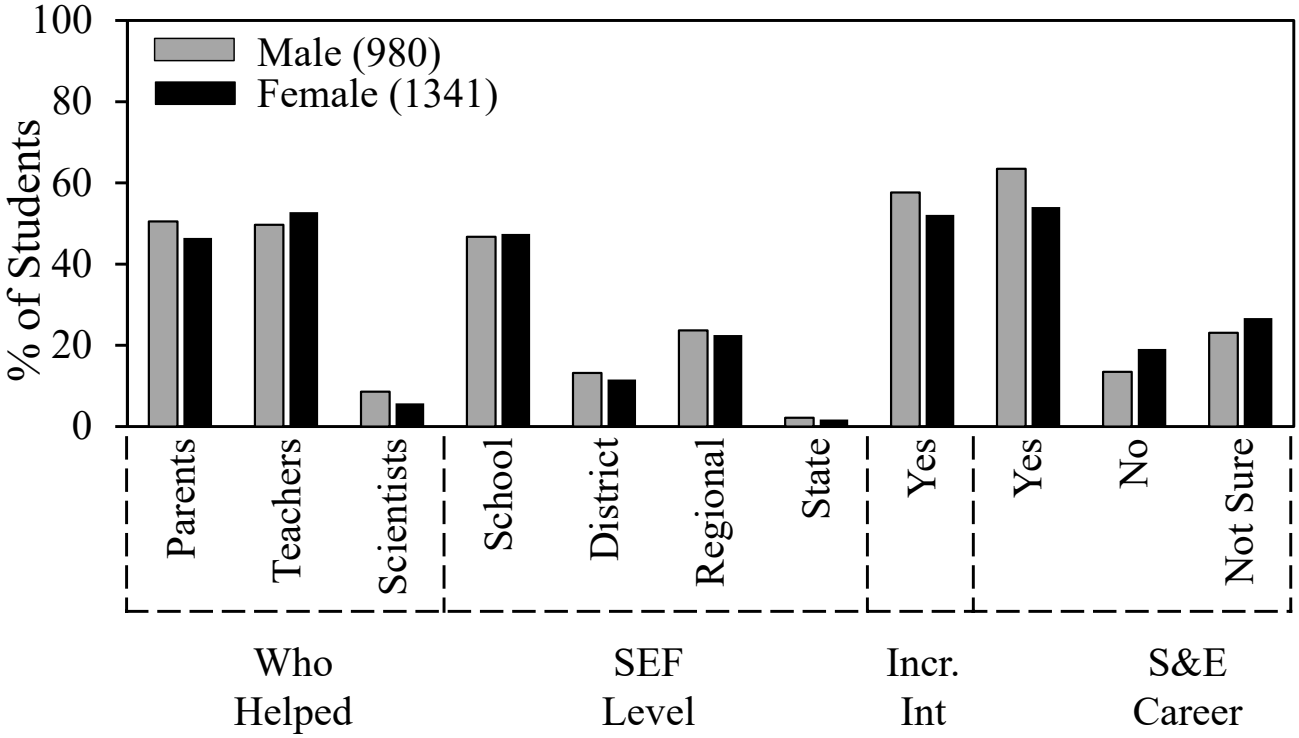


Figure 6. Student gender, location, and ethnicity



SEF Survey Students	Distribution by Gender		
	Male - #	**Female - #**	**Girls/Boys**
All	980	1341	1.37
Suburban	777	997	1.28
Urban	203	344	1.69
Asian	396	435	1.10
Black	64	158	2.47
Hispanic	156	225	1.44
White	326	448	1.37

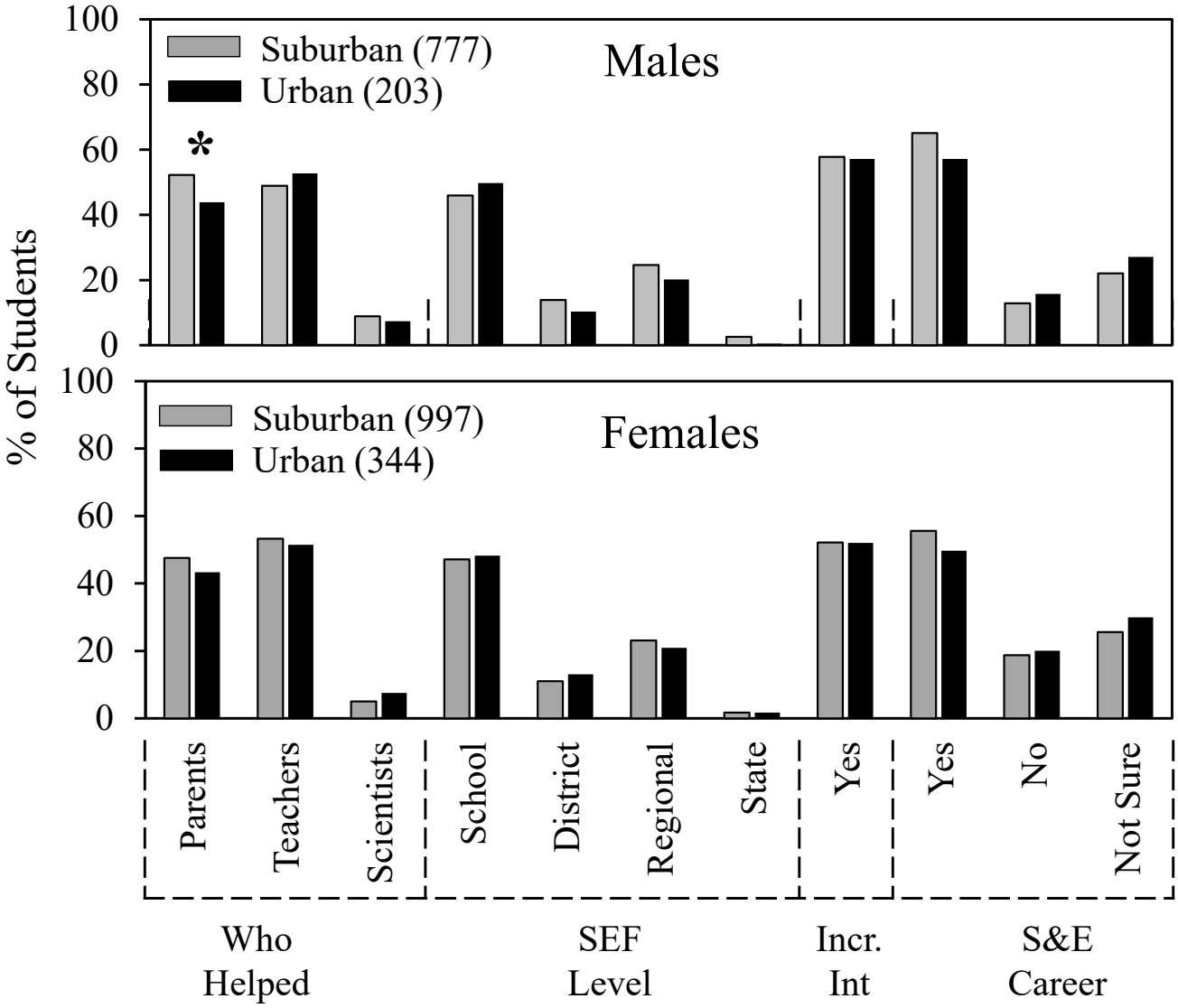
Figure 7. Gender and SEF experience



Survey Questions	Answers	Gender (# Students)		
		Male (980)	Female (1341)	P Value
		Answer % (#)		
Who helped you with your SEF project? (inclusive)	Parents	50.5 (495)	46.5 (623)	.054
	Teachers	49.7 (487)	52.8 (708)	.140
	Scientists	8.6 (84)	5.7 (76)	.006
Highest level of SEF competition?*	School	46.7 (458)	47.4 (636)	.542
	District	13.2 (129)	11.6 (155)	
	Regional	23.7 (232)	22.5 (302)	
	State	2.1 (21)	1.7 (23)	
SEF increased your interest in S&E?	Yes	57.7 (565)	52.1 (699)	.008
Interest in an S&E Career	Yes	63.5 (622)	54.1 (725)	<.001
	No	13.5 (132)	19.1 (256)	
	Not Sure	23.1 (226)	26.7 (358)	

*Answer completion rate >96.5% except for the question about level of SEF competition, which averaged 83%.

Figure 8. School location, gender and SEF experience



Supplemental Table 1. Student survey answers year-to-year

Survey Questions	Answers	Year (# Students*)		
		2020 (900)	2021 (583)	2022 (951)
		Student Answers %		
1. What grade are you in?	9th	43.2	45.3	41.1
	10th	34.0	31.0	32.9
	11th	16.9	17.7	17.9
	12th	5.8	5.8	7.9
2. Location of high school	Suburban	73.4	72.6	75.1
	Urban	21.6	25.7	22.0
	Rural	5.0	1.7	2.9
3. Gender?	Male	40.8	39.5	44.2
	Female	59.0	59.9	53.3
4. Ethnicity most identified with?	Asian	35.4	35.5	33.3
	Black	8.8	11.5	9.3
	Hispanic	17.2	19.2	15.0
	White	33.8	28.0	37.4
	Other	4.1	5.3	4.2
5. During high school have you carried out science fair more than once?	Yes	38.0	41.9	31.9
	No	61.9	58.1	67.6
6. In which science fair competitions did you compete this year?	School	50.1	40.7	46.9
	District	8.9	14.2	14.4
	Regional	22.0	27.3	21.3
	State	1.4	1.5	2.6
7. Was your science fair project Team or Individual?	Individual	58.8	74.4	63.4
	Team	37.8	21.8	33.8
8. Was the science fair project required by your school?	Yes	63.8	53.9	65.4
	No	19.0	26.9	16.4
	Satisfied School Project	14.3	15.6	15.4
9. Do you think science fair projects should be optional or required? (Need not be for competition.)	Optional	75.6	76.5	74.0
	Required	23.1	21.6	24.6
10. Do you think science fair projects for competition should be optional or required?	Optional	83.9	85.6	87.3
	Required	13.8	12.2	11.5
	1. Parents	48.0	45.5	49.2

11. Who actually helped you?	2. Siblings	10.9	12.2	12.7
	3. Other family members	5.0	4.3	4.7
	4. Teachers	52.4	49.7	52.7
	5. Other students	30.7	18.9	31.9
	6. Scientists	8.1	7.2	6.2
	7. A paid mentor	0.3	0.7	1.1
	8. Articles on the Internet	57.9	61.1	57.3
	Articles in books or magazines	22.9	28.1	20.4
	Other	3.0	3.9	3.0
12. What kind of help did you actually receive?	1. Being given the main idea	9.0	8.2	11.1
	2. Development of the idea	26.7	28.8	31.0
	3. Gathering background research information, or finding a research site or participants	25.1	23.0	44.3
	4. Performing the experiments	28.7	23.7	35.6
	5. Writing the report	9.1	8.2	13.1
	6. Fine tuning the report after it is written	33.2	35.5	29.0
	7. Designing the poster board and presentation	22.2	12.3	20.1
	8. Producing charts or graphs	14.1	10.5	16.3
	9. Coaching for the interview with judges	20.8	19.4	9.9
	10. Copying the project from someone else	0.7	0.3	0.7
	Other	6.1	8.7	4.8
13. Did you get the kind of help you wanted from teachers?	Yes	74.8	76.7	81.7
	No	24.2	21.4	15.4
14. Did you get the amount of help you wanted from teachers?	Yes	73.4	75.6	80.4
	No	25.0	22.0	16.5
15. What types of communications did you use in your science fair presentation?	Written report	0.0	0.0	50.8
	Literature review	0.0	0.0	15.4
	Research notebook	0.0	0.0	30.5
	Poster board presentation	0.0	0.0	59.0
	Power point presentation	0.0	0.0	44.2
	Software to show results	0.0	0.0	45.4
	Interview with judges	0.0	0.0	40.7
	Other	0.0	0.0	2.3
16. What obstacles did you face?	1. Coming up with the main idea	45.8	43.6	44.4
	2. Getting motivated to do the project	43.2	41.2	46.8
	3. Becoming disappointed with the project	26.1	20.2	22.9
	4. Limited resources	38.9	39.1	31.8
	5. Limited knowledge	31.6	29.7	24.5
	6. Limited skills	25.0	21.3	17.7
	7. Limited cooperation	12.9	9.4	11.6
	8. Getting organized	26.3	23.8	25.1

	9. Time pressure	63.0	60.4	58.9
	10. Not enough money	17.1	10.6	9.5
	11. Results not as expected	22.7	17.0	25.0
	Other	3.4	3.9	3.5
17. How did you overcome the obstacles?	1. Used someone else's main idea	0.9	1.7	1.3
	2. Picked a familiar / interesting topic	31.0	32.2	30.9
	3. Did more background research	50.1	54.0	44.8
	4. Stopped working on the project for a while	15.8	17.2	17.9
	5. Made a timeline to follow	22.7	29.3	25.9
	6. Perseverance and self-discipline	48.4	49.7	50.1
	7. Had someone else to keep me on track	15.9	15.1	14.4
	8. Had someone else do the math	1.4	1.2	0.3
	9. Changed the research plan	19.1	22.6	17.7
	10. Collected more data	24.2	27.3	24.7
	11. Had someone else collect the data	2.2	0.7	1.3
	12. Used someone else's data	0.6	1.5	0.6
	13. Made up the data	3.6	2.2	1.6
	14. Changed the hypothesis to fit the data	3.9	4.8	3.0
	15. Changed the data to fit the hypothesis	1.6	1.9	1.1
	Other	4.4	3.9	4.5
20. Are you interested in a career in the sciences or engineering?	Yes	55.3	60.9	58.4
	No	19.1	14.4	16.1
	Not Sure	25.4	24.5	25.6
21. Did your science fair experience increase your interest in the sciences or engineering?	Yes	55.9	57.8	51.9
	No	43.7	41.5	46.9
*Number of incomplete surveys not included: 2020, 138; 2021, 102; 2022, 189				

Supplemental Table 2. School location, ethnicity, and SEF experience

Survey Questions	Answers	School Location		p Value
		Suburban	Urban	
		Student Answers % (#)		
Asian Students #		**681**	**154**	
Who helped you with your SEF project? (more than one answer possible)	Parents	46.3 (315)	41.6 (64)	0.290
	Teachers	51.4 (350)	51.9 (80)	0.901
	Scientists	10.4 (71)	10.4 (16)	0.989
Kind of help received	Fine tuning report	29.5 (201)	36.4 (56)	0.096
	Coaching interview	21.6 (147)	16.9 (26)	0.193
Highest level of SEF competition?	School	42.8 (257)	56.6 (69)	0.038
	District	14.8 (89)	10.7 (13)	
	Regional	38.6 (232)	31.1 (38)	
	State	3.8 (23)	1.6 (2)	
SEF Increased Interest	Yes	68.4 (466)	61.0 (94)	0.078
Interest in S&E Career	Yes	70.6 (481)	60.4 (93)	0.041
	No	8.2 (56)	12.3 (19)	
	Not Sure	21.1 (144)	27.3 (42)	
Black Students #		**159**	**65**	
Who helped you with your SEF project? (more than one answer possible)	Parents	42.1 (67)	41.5 (27)	0.934
	Teachers	47.8 (76)	49.2 (32)	0.846
	Scientists	2.5 (4)	3.1 (2)	0.813
Kind of help received	Fine tuning report	28.9 (46)	27.7 (18)	0.852
	Coaching interview	10.7 (17)	13.8 (9)	0.504
Highest level of SEF competition?	School	69.7 (85)	73.2 (41)	0.831
	District	10.7 (13)	7.1 (4)	
	Regional	18.9 (23)	19.6 (11)	
	State	0.8 (1)	0.0 (0)	
SEF Increased Interest	Yes	39.6 (63)	41.5 (27)	0.791
Interest in S&E Career	Yes	49.7 (79)	43.1 (28)	0.632
	No	26.4 (42)	29.2 (19)	
	Not Sure	23.3 (37)	27.7 (18)	
Hispanic Students #		**225**	**158**	
Who helped you with your SEF project? (more than one answer possible)	Parents	42.7 (96)	38.6 (61)	0.426
	Teachers	51.1 (115)	49.4 (78)	0.737
	Scientists	6.7 (15)	6.3 (10)	0.895
Kind of help received	Fine tuning report	31.1 (70)	21.5 (34)	0.038
	Coaching interview	17.3 (39)	13.9 (22)	0.369
Highest level of SEF competition?	School	43.5 (84)	49.6 (65)	0.627
	District	23.3 (45)	22.9 (30)	

	Regional	30.6 (59)	24.4 (32)	
	State	2.6 (5)	3.1 (4)	
SEF Increased Interest	Yes	59.6 (134)	60.1 (95)	0.911
Interest in S&E Career	Yes	58.7 (132)	51.9 (82)	0.384
	No	18.2 (41)	19.6 (31)	
	Not Sure	23.1 (52)	28.5 (45)	
White Students #		**641**	**151**	
Who helped you with your SEF project? (more than one answer possible)	Parents	56.2 (360)	51.7 (78)	0.316
	Teachers	51.2 (328)	55.0 (83)	0.401
	Scientists	4.1 (26)	8.6 (13)	0.02
Kind of help received	Fine tuning report	36.2 (232)	41.7 (63)	0.206
	Coaching interview	12.9 (83)	15.9 (24)	0.341
Highest level of SEF competition?	School	67.0 (349)	64.6 (82)	0.709
	District	12.9 (67)	13.4 (17)	
	Regional	18.4 (96)	22.0 (28)	
	State	1.7 (9)	0.0 (0)	
SEF Increased Interest	Yes	42.1 (270)	42.4 (64)	0.953
Interest in S&E Career	Yes	52.7 (338)	49.0 (74)	0.512
	No	21.1 (135)	19.2 (29)	
	Not Sure	26.2 (168)	30.5 (46)	

Supplemental Table 3. School location, gender, and SEF experience

Survey Questions	Answers	Location		p Value
		Suburban	Urban	
		Student Answers % (#)		
Males #		**777**	**203**	
Who helped you with your SEF project? (inclusive)	Parents	52.3 (406)	43.8 (89)	0.033
	Teachers	48.9 (380)	52.7 (107)	0.334
	Scientists	8.9 (69)	7.4 (15)	0.499
Highest level of SEF competition?	School	45.9 (357)	49.8 (101)	0.105
	District	13.9 (108)	10.3 (21)	
	Regional	24.6 (191)	20.2 (41)	
	State	2.6 (20)	0.5 (1)	
SEF increased your interest in S&E	Yes	57.8 (449)	57.1 (116)	0.869
Interest in an S&E Career	Yes	65.1 (506)	57.1 (116)	0.110
	No	12.9 (100)	15.8 (32)	
	Not Sure	22.0 (171)	27.1 (55)	
Females #		**997**	**344**	
Who helped you with your SEF project? (inclusive)	Parents	47.5 (474)	43.3 (149)	0.175
	Teachers	53.3 (531)	51.5 (177)	0.563
	Scientists	5.0 (50)	7.6 (26)	0.079
Highest level of SEF competition?	School	47.1 (470)	48.3 (166)	0.688
	District	11.0 (110)	13.1 (45)	
	Regional	23.1 (230)	20.9 (72)	
	State	1.7 (17)	1.7 (6)	
SEF increased your interest in S&E	Yes	52.2 (520)	52.0 (179)	0.969
Interest in an S&E Career	Yes	55.6 (554)	49.7 (171)	0.159
	No	18.8 (187)	20.1 (69)	
	Not Sure	25.6 (255)	29.9 (103)	