Women in STEM

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Goals

- ## Queries

  1. What has been the ethnic distribution of women in STEM jobs over the years in the US?
  2. What is the income comparison between employed men and women who have a STEM degree?
  3. What is the difference in the number of men and women being awarded bachelor's degrees in the STEM field in the US?
  4. What is the ethnic breakdown of female STEM undergraduates overall in the US?
  5. Which STEM field has the highest number of women joining per year?
  6. What is the relationship between the highest degree women have and their STEM field?

- ## Hypotheses

  1. The average percentage of women in STEM jobs is the same in the northern US as in the South.
  2. The average percent of ethnic minority women enrolled in STEM bachelor's degree programs is 30%.

Data

- **Data sources**: National Center for Science and Engineering Statistics (NCSES), National Science Board (NSB), Wikipedia, Status of Women Data, Spurious Correlations, United States Census Bureau, and GIS Data

- **Data schema**: Rows were STEM majors or jobs, ethnicity and/or state. Columns were years, salary, percentage of people, income, degree, number of businesses, and/or ethnicities.

- **Preparation**: Data was categorized by STEM major or job and merged in Excel and Minitab with "na" data deleted

- **Challenges**: Finding enough data, merging and cleaning the data, and choosing best visual representations
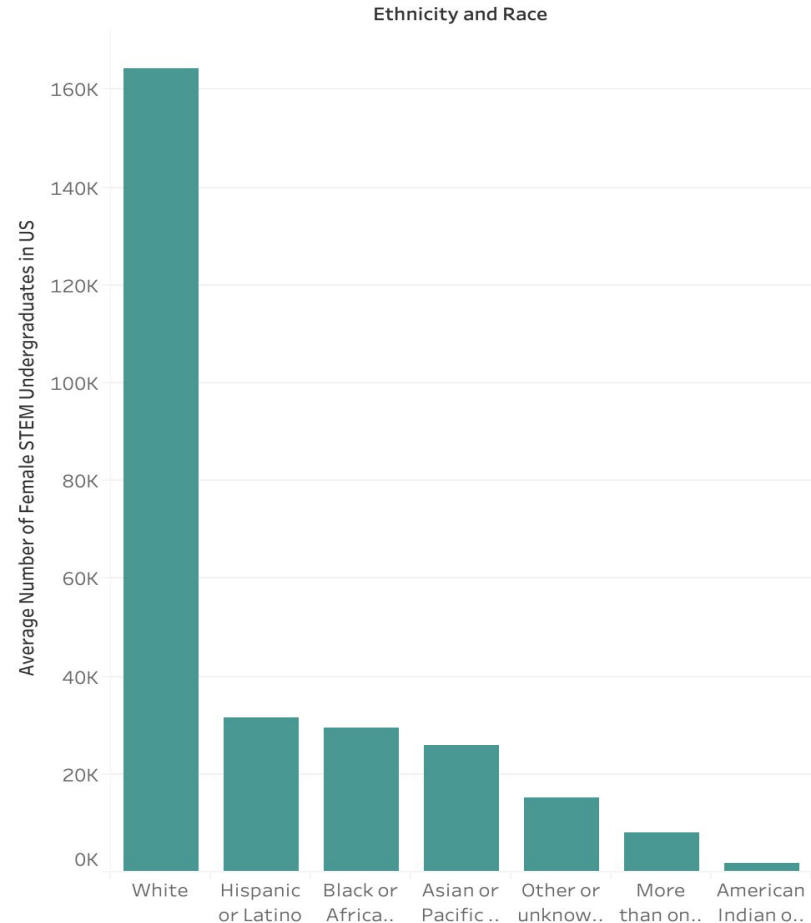
Analysis

- **Query 1**: What has been the ethnic distribution of women in STEM jobs over the years in the US?

- **Outcome**: White women predominates all fields in science and engineering: 50,252 per year on average. Every minority groups also increase gradually. Hispanic group shows the largest growth over the years.

Female with STEM Jobs Distributed by Race and Ethnicity from 2008 to 2017
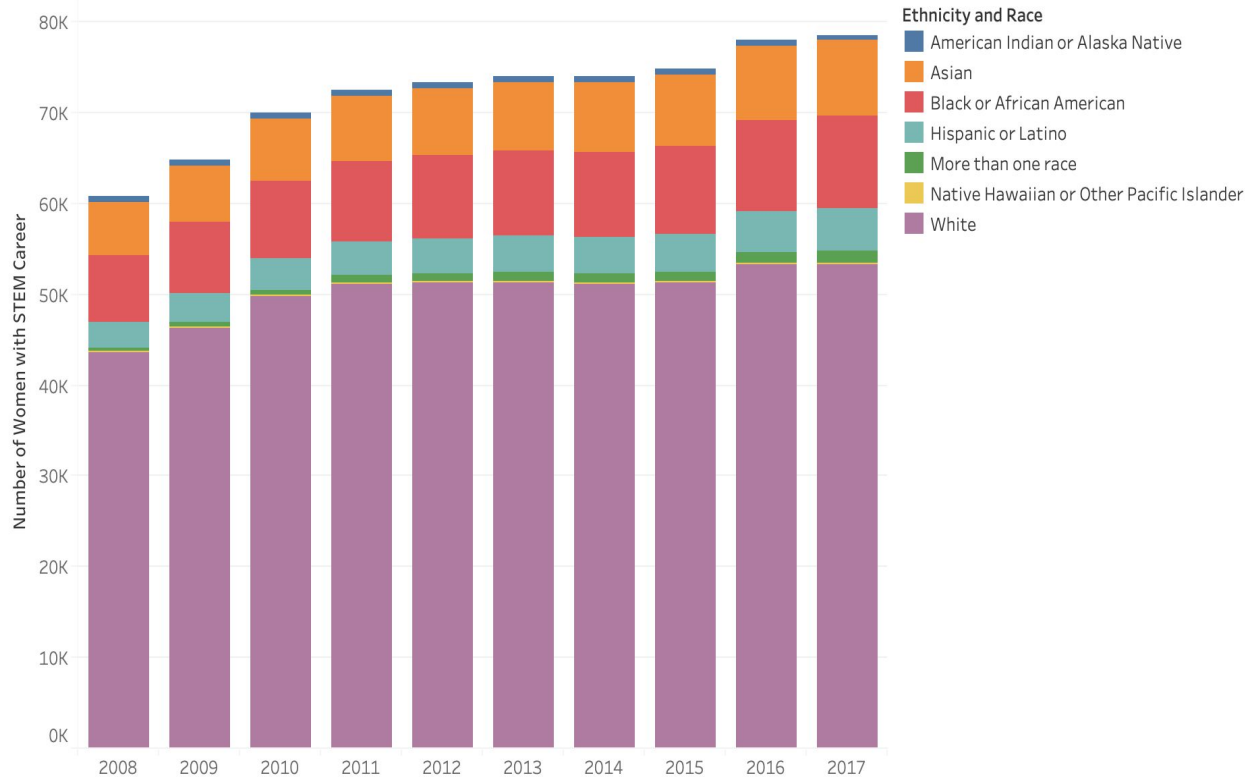
Analysis

- **Query 4**: What is the ethnic breakdown of female STEM undergraduates overall in the US?

- **Outcome**: White women dominates all fields of STEM majors with an average number of 164,416 undergraduates per year followed Hispanic women of 31,652 undergraduates. There are 25,859 Asian or Pacific Islander female undergraduates. Lastly, there are 29,491 American Indian or Native Alaskan undergraduates.

Female STEM Undergraduates Distributed among Race and Ethnicity

Ethnicity and Race

Analysis

- **Query 3**: What is the difference in the number of men and women being awarded bachelor's degrees in the STEM field in the US?

- **Correlation**: 0.999

- **Outcome**: On average, about 2970 more women than men per year are awarded STEM bachelor's degrees in the US.

Earned STEM Bachelor's by Males vs. Females
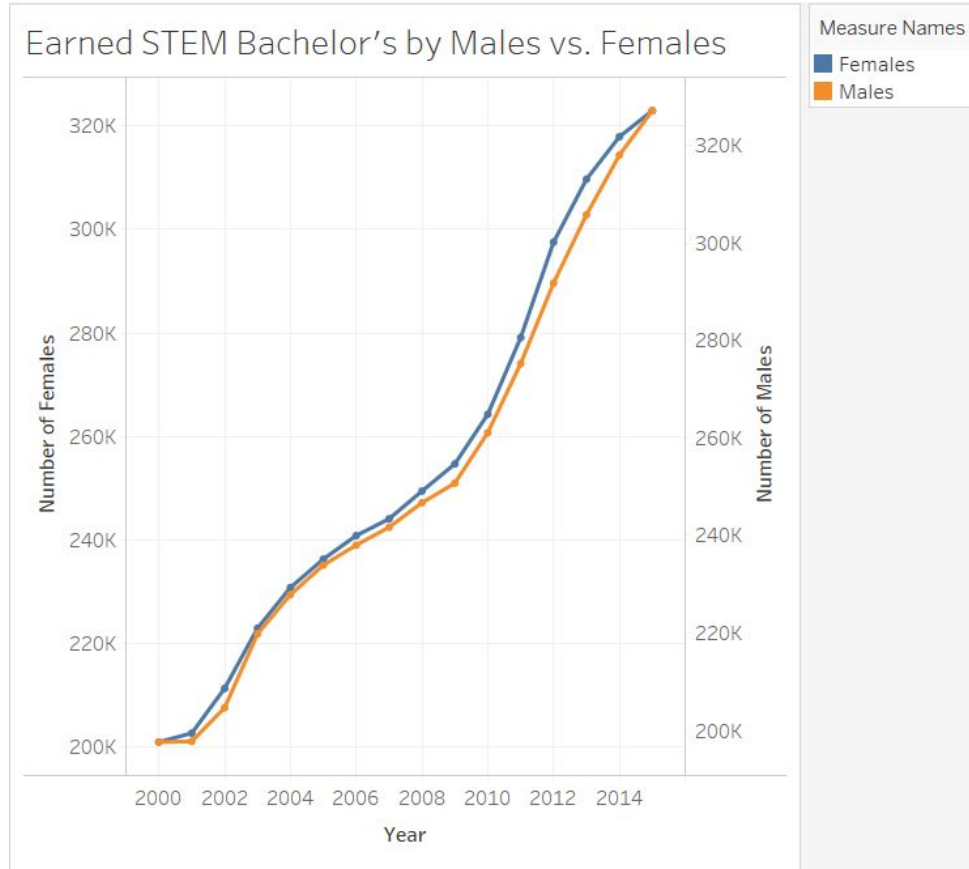
Analysis

- **Query 5**: Which STEM field has the highest number of women joining per year?

- **Outcome**:
  - <u>Highest</u> - Psychology: 72,448
 - <u>Lowest</u> - History of Science: 66

Average Number of Females with STEM Bachelor's per Major
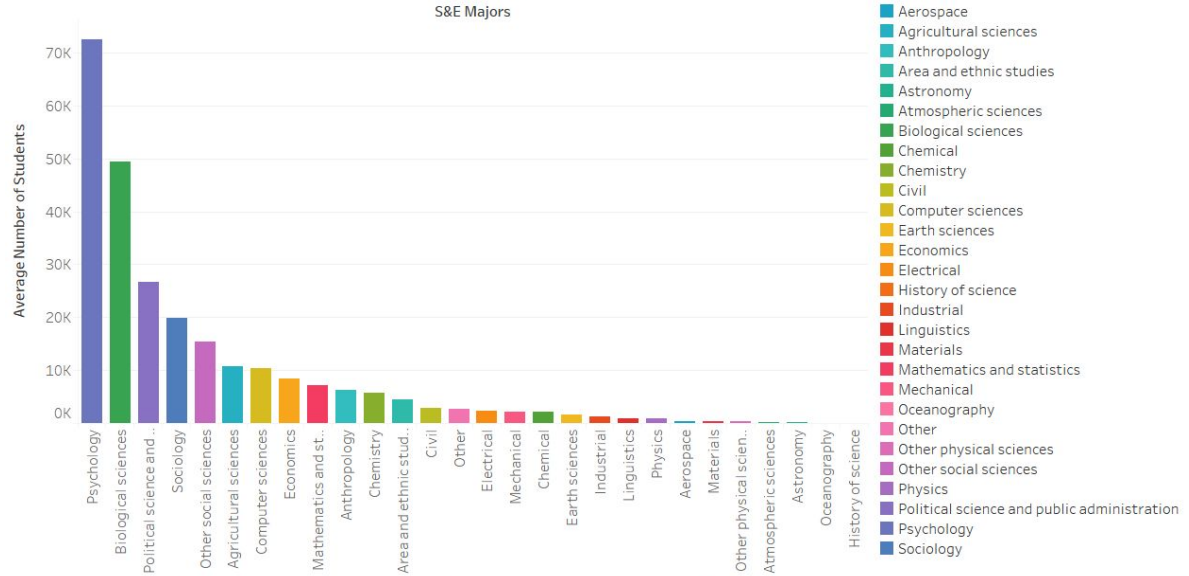
Analysis

- **Query 6**: What is the relationship between the highest degree women have and their STEM field?

- **Outcome**: Most women in STEM have a master's as their highest degree, except electrical engineers; they have a doctorate as their highest (1,773).
  - <u>Highest</u> - Psychology: 36,151
 - <u>Lowest</u> - History of Science: 35

Average Number of Females with Highest Degree per STEM field

Analysis
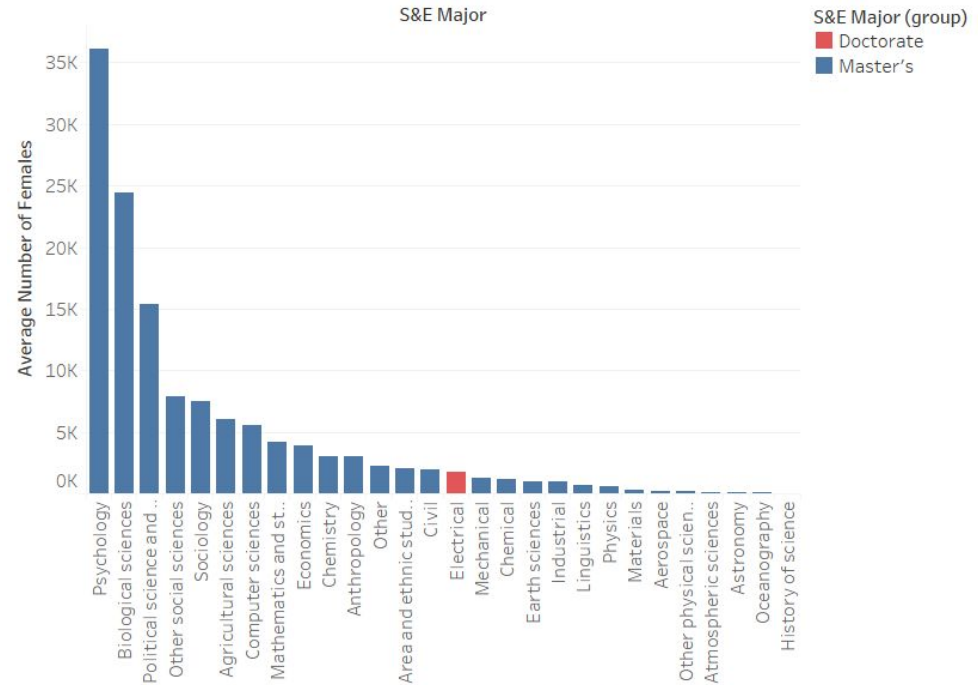
Income between Men and Women Based on 9 Majors

- **Query 2**: What is the income comparison between employed men and women who have a STEM degree?

- **Outcome**: Women earn an average of about $2111.11 more than men in most majors.
  - Hypothesis test shows that the incomes are the same between both genders in 2010
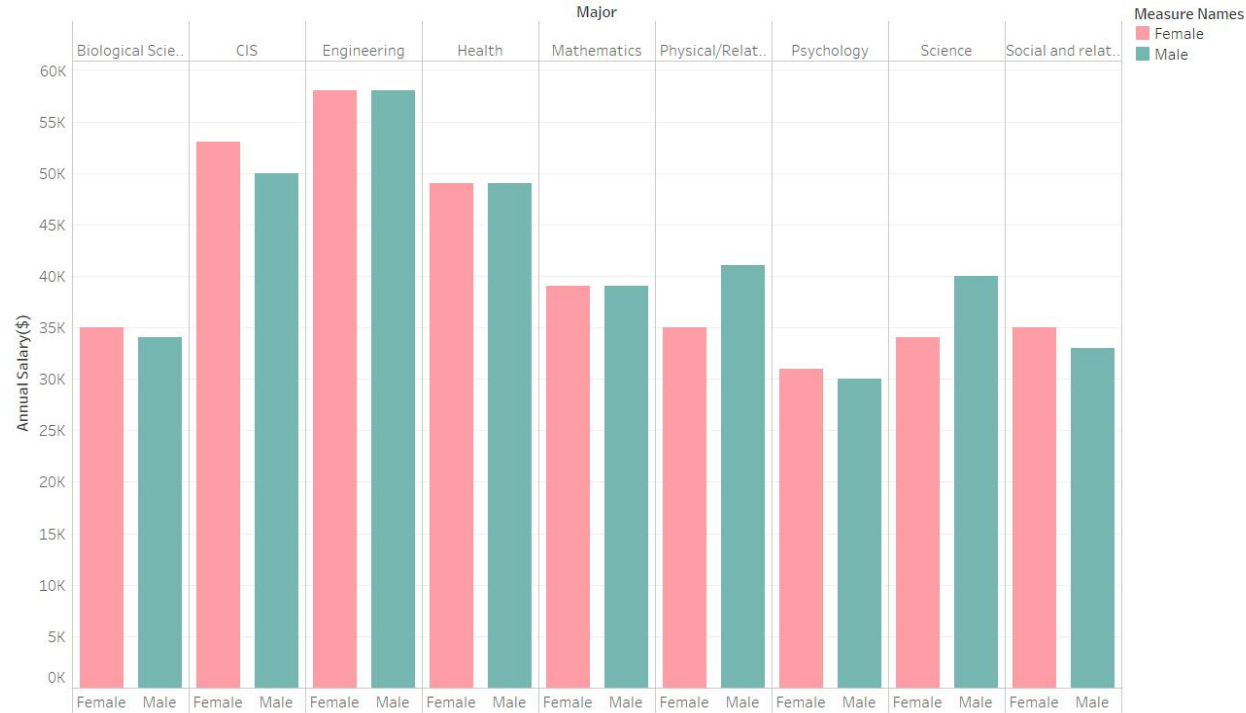
Analysis

- **Hypothesis 1**: The average percentage of women in STEM jobs is the same in the northern US as in the South.

- **Outcome**: The average percent of women in STEM jobs is the same in the northern US as in the South.

Percent of Women in STEM Jobs Based on States

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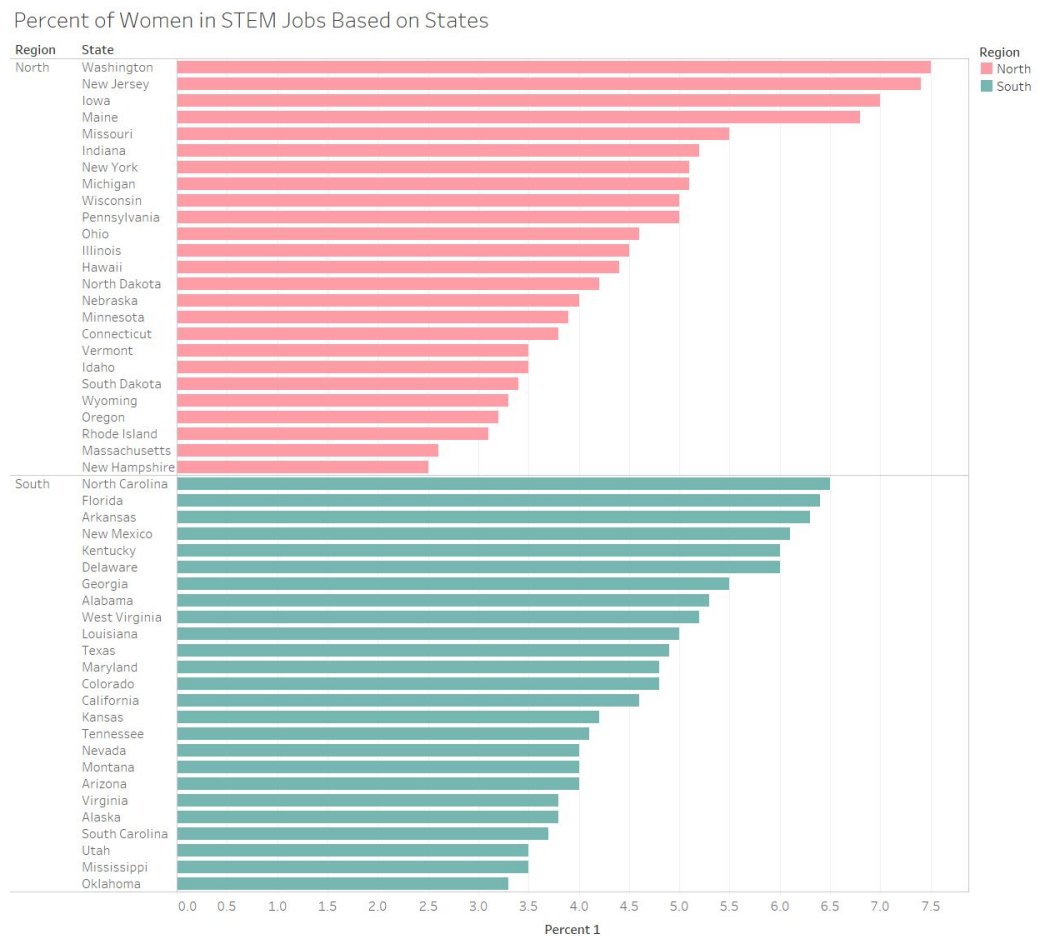
Analysis

- **Hypothesis 2**: The average percent of ethnic minority women enrolled in STEM bachelor's degree programs is 30%.

- **Outcome**: The number of colored women in STEM undergraduate programs is greater than 30% each year

Percent of Colored Women In Bachelor's Programs Per Year
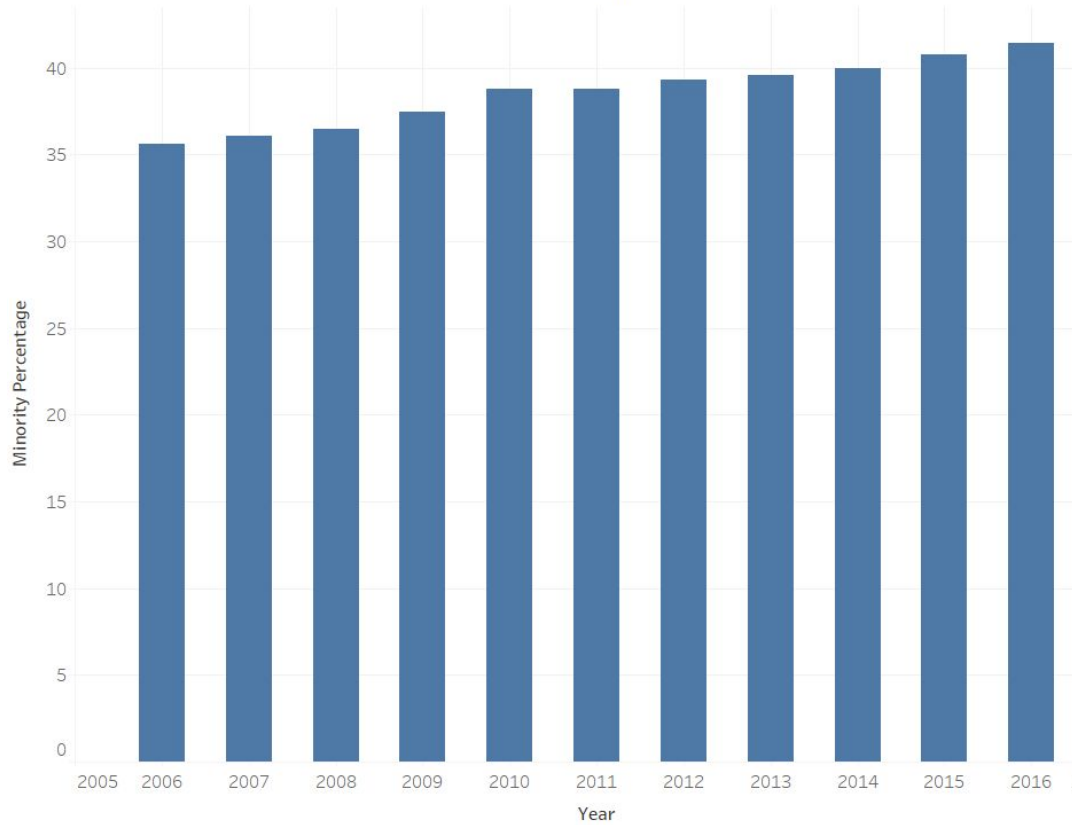
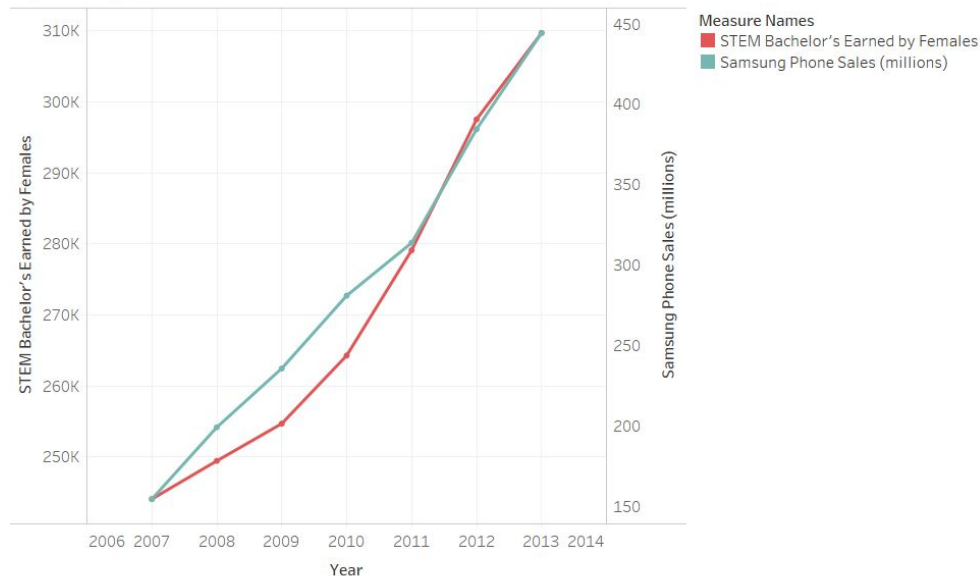# Insights

Earned STEM Bachelor's by Females and Apple iPhone Sales
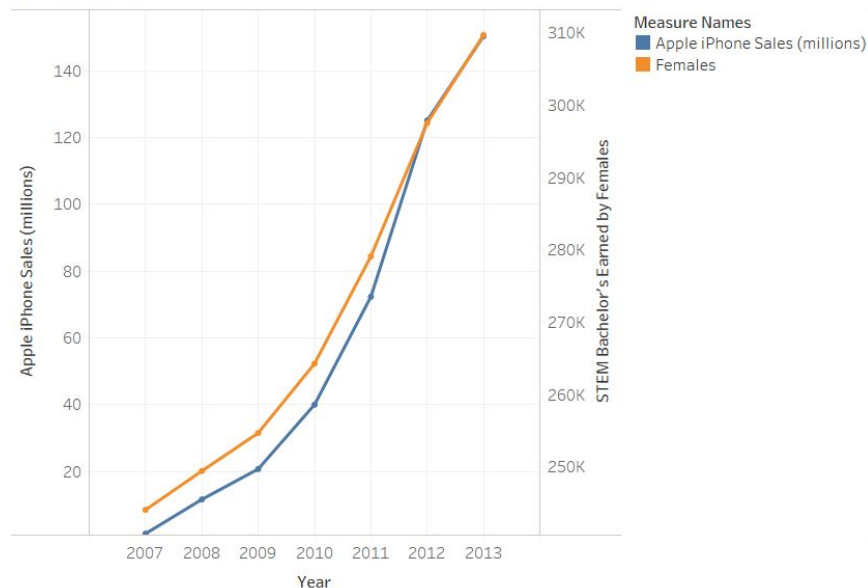
Correlation: 0.998

Earned STEM Bachelor's by Females and Samsung Phone Sales

Correlation: 0.989

Insights

Percent of Women Employed in STEM, Total Businesses, and Household Income Per State

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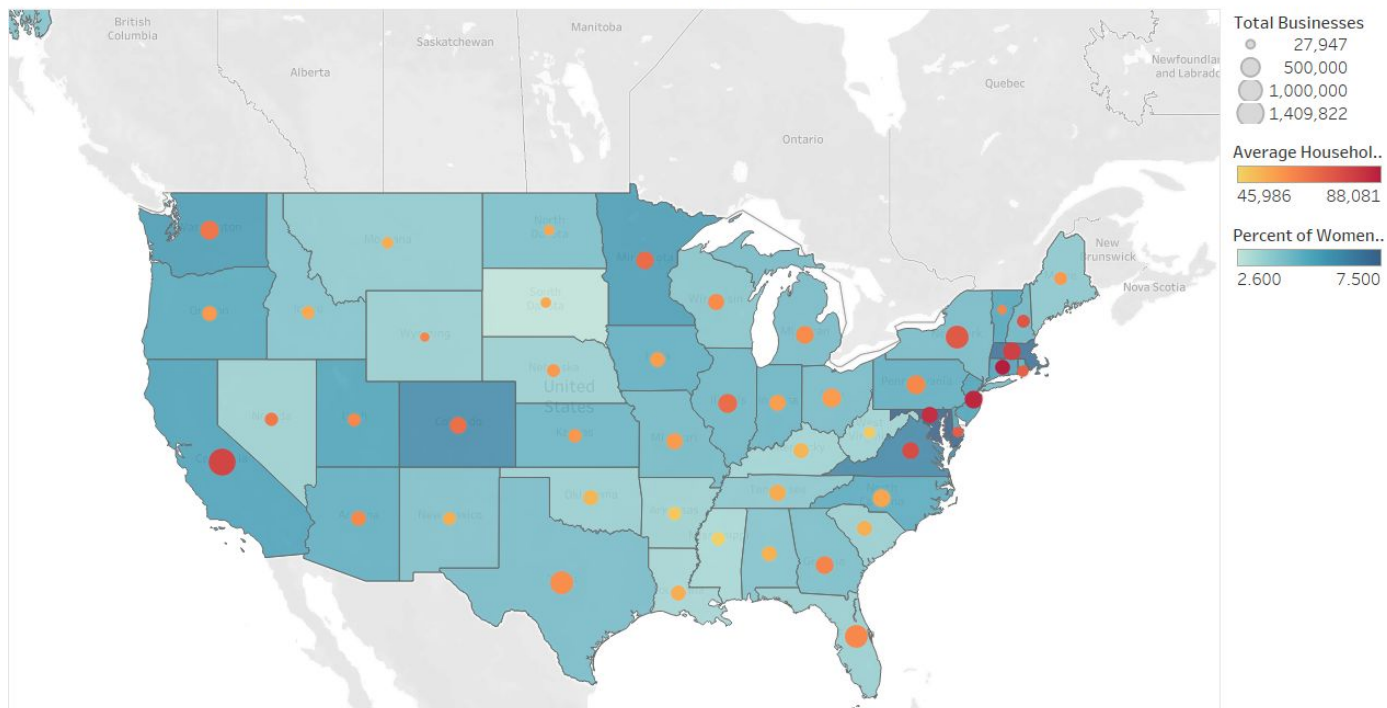
Appendix

Query 1

- Bar graph made using Minitab represents different ethnic and racial groups by stacking from the largest to smallest groups through 2008 to 2017.

Female Ethnic and Racial Distribution of STEM Jobs vs Time

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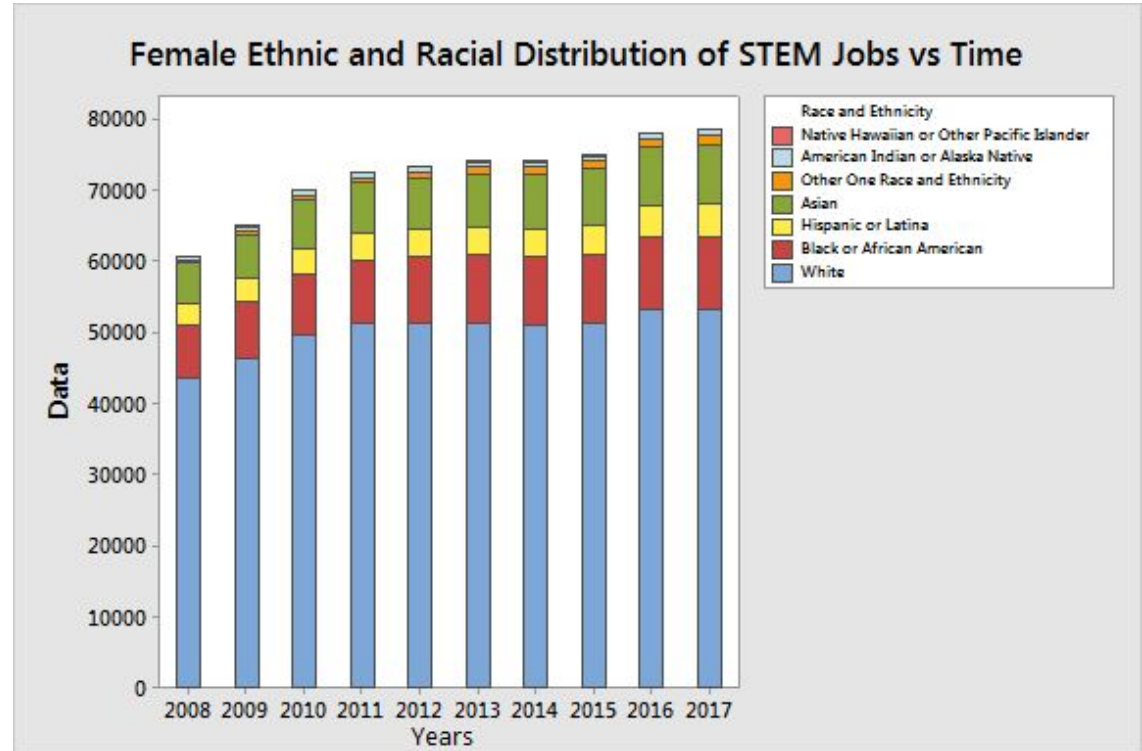
Query 1 (cont.)

- Correlation: 0.970

- However, this graph shows the large gap between the Hispanic or Latina women with STEM jobs and the US female population for Hispanic or Latina women.

Ethnic and Racial Distribution of Women in STEM Jobs and US Female Population between 2008 and 2017

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Query 1 (cont.)

Percentage Difference in Ethnicity and Race of STEM Undergraduates in US Female Population between 2008 and 2017
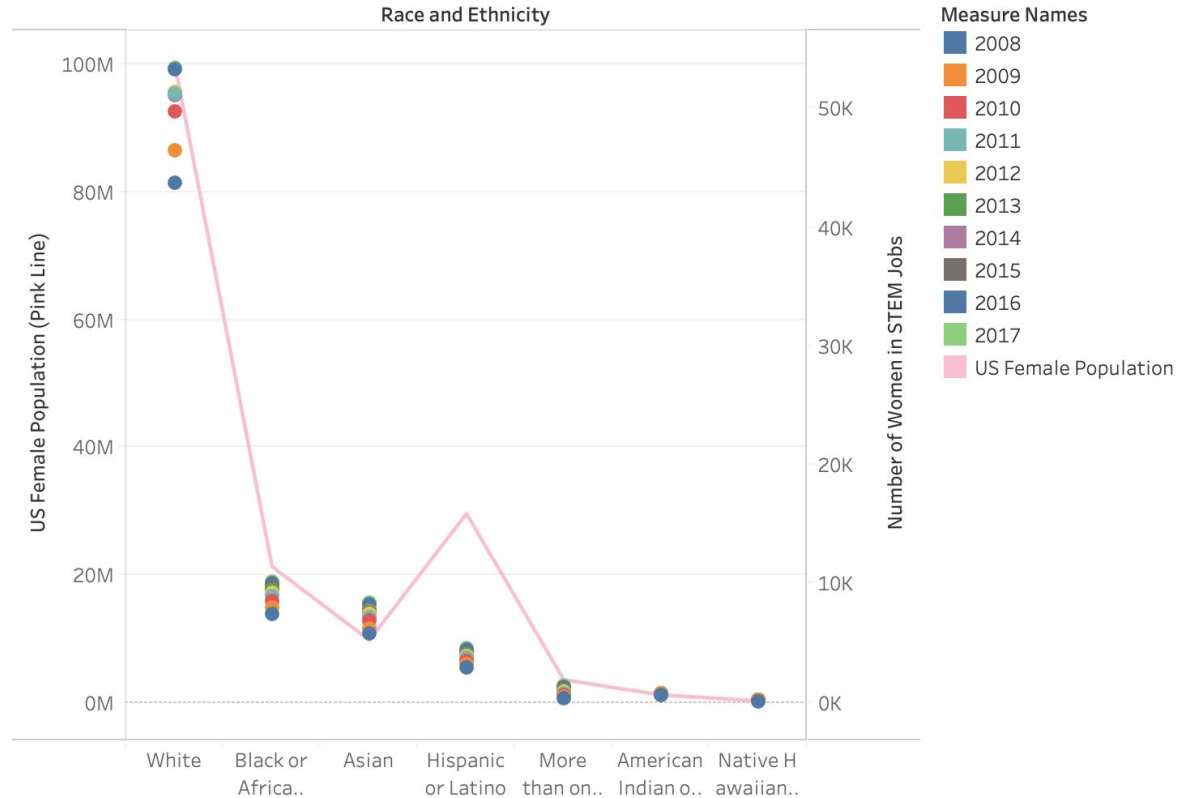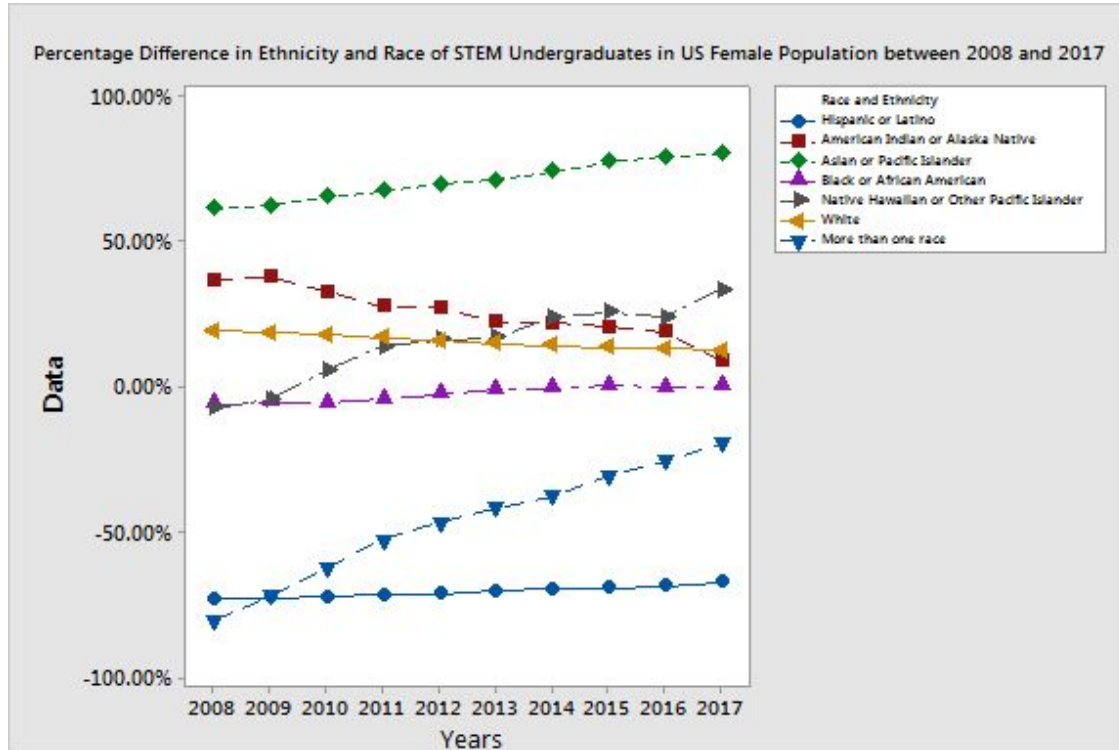
- This graph shows which ethnicity or racial group has the highest number of STEM jobs within their US female population racial and ethnicity group.

   -On average, 68% Asian or Pacific Islander women have STEM related jobs out of the total female Asian or Pacific Islanders in US

   -Higher the percentage, more women has STEM job within their own ethnicity group

Query 2

- Plotted the incomes between genders per major
- Used this to calculate the average difference of about $2,000 in the income gap

Chart of Female, Male
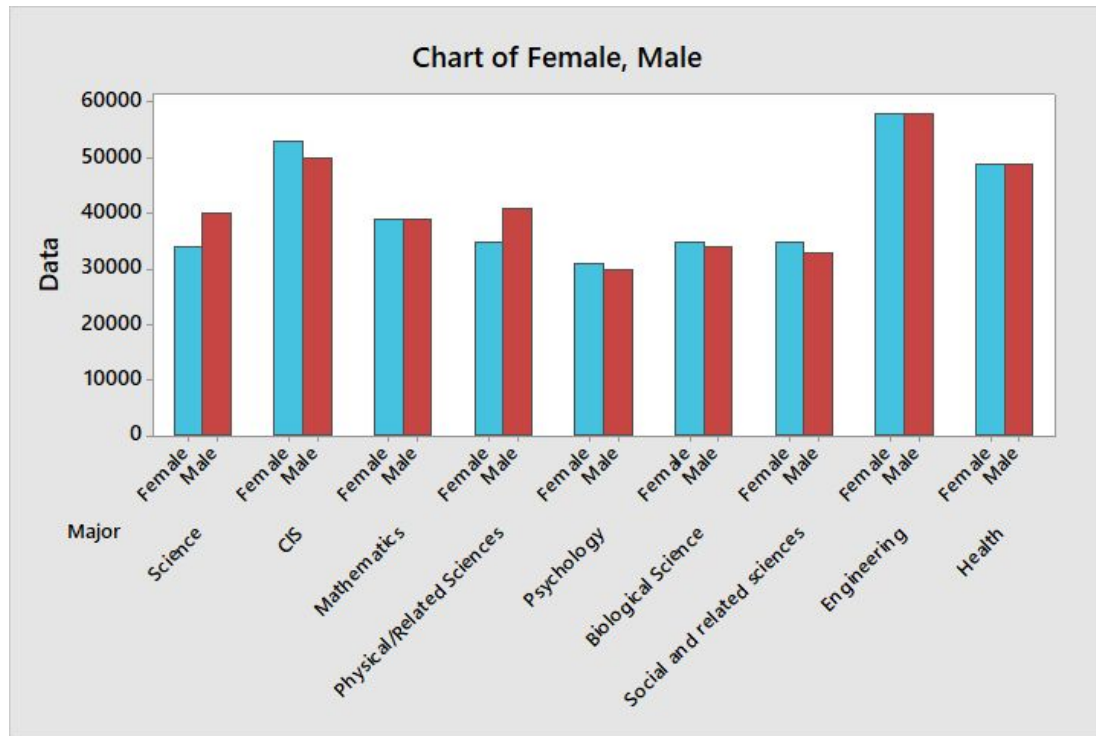
Query 2 (cont.)

- Hypothesis test (Z Test for 2 Population Means) to see if there is an income comparison between women and men with STEM degrees.

- Null hypothesis is not rejected. There is no income comparison between women and men both with STEM degree.

Z-test for 2 Population Means

STEP 1) $u_1 - u_2$

$u_1 =$ true average Female income with STEM Degree

$u_2 =$ true average Male income with STEM Degree

STEP 2) $H_0: u_1 - u_2 = 0$

STEP 3) $H_a: u_1 - u_2 > 0$

STEP 4) $\Delta_0 = 0$, the test statistical value is $Z = \dfrac{\bar{x} - \bar{y} - \Delta_0}{\sqrt{\dfrac{\sigma_1^2}{m} + \dfrac{\sigma_2^2}{n}}}$

STEP 5) $m = 9 \quad \bar{x} = 41000 \quad \sigma_1 = 9177$
$n = 9 \quad \bar{y} = 41556 \quad \sigma_2 = 8630$

$Z = \dfrac{41000 - 41556 - 0}{\sqrt{\dfrac{9177^2}{9} + \dfrac{8630^2}{9}}} = -0.13$

$Z = -0.13$

STEP 6) The $>$ implies an upper-tailed test.
$P\text{-value} = 1 - \Phi(z) = 1 - \Phi(-.13) = 1 - .4483 = 0.5517$

STEP 7) $P\text{-value} \approx .5517 > .1 = \alpha$
Therefore, H_0 is not rejected.
There is no difference in income between employed men and women who have a STEM degree.

Query 3

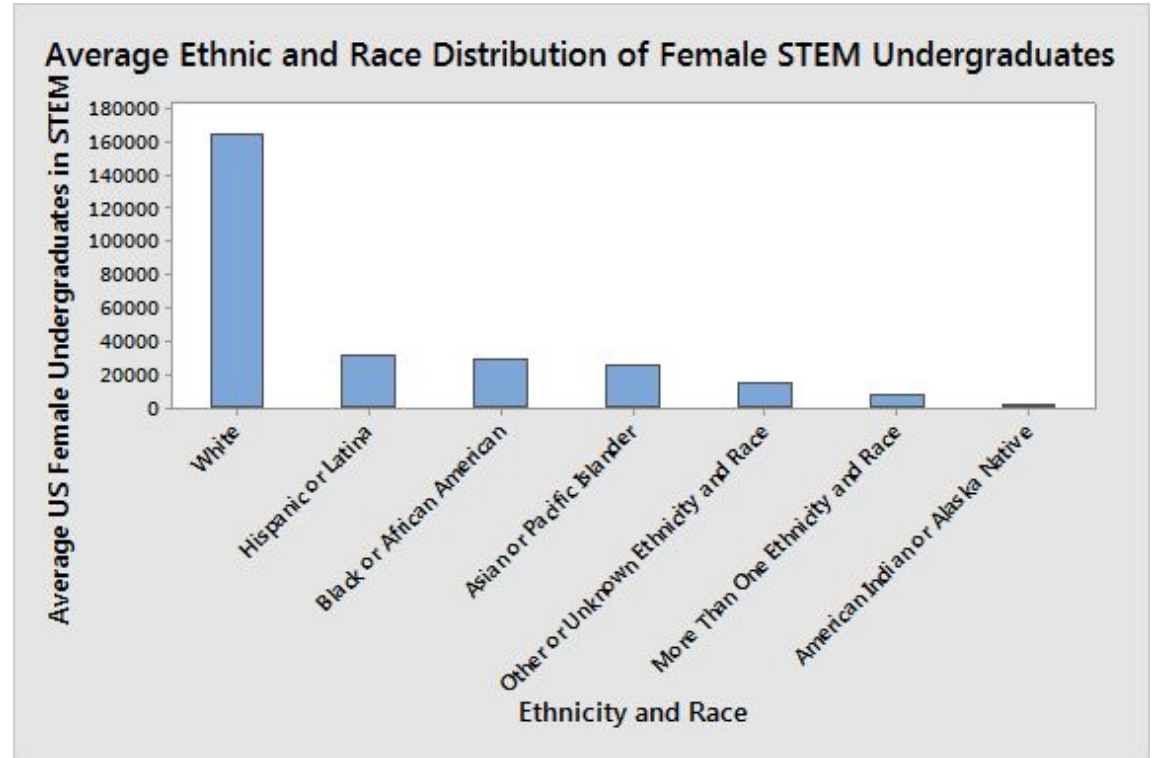| Year	Males	Females	Difference	Sum of Difference	Average Difference
2000	197650	200952	3302	47522	2970.13
2001	197771	202664	4893		
2002	204675	211308	6633		
2003	219815	222940	3125		
2004	227861	230797	2936		
2005	233924	236290	2366		
2006	238029	240829	2800		
2007	241697	244075	2378		
2008	246719	249449	2730		
2009	250742	254693	3951		
2010	261091	264283	3192		
2011	275258	279107	3849		
2012	291791	297539	5748		
2013	305777	309698	3921		
2014	318015	317900	-115		
2015	327122	322935	-4187		

Query 3 (cont.)

- Calculated average difference between males and females earning STEM bachelor's degrees

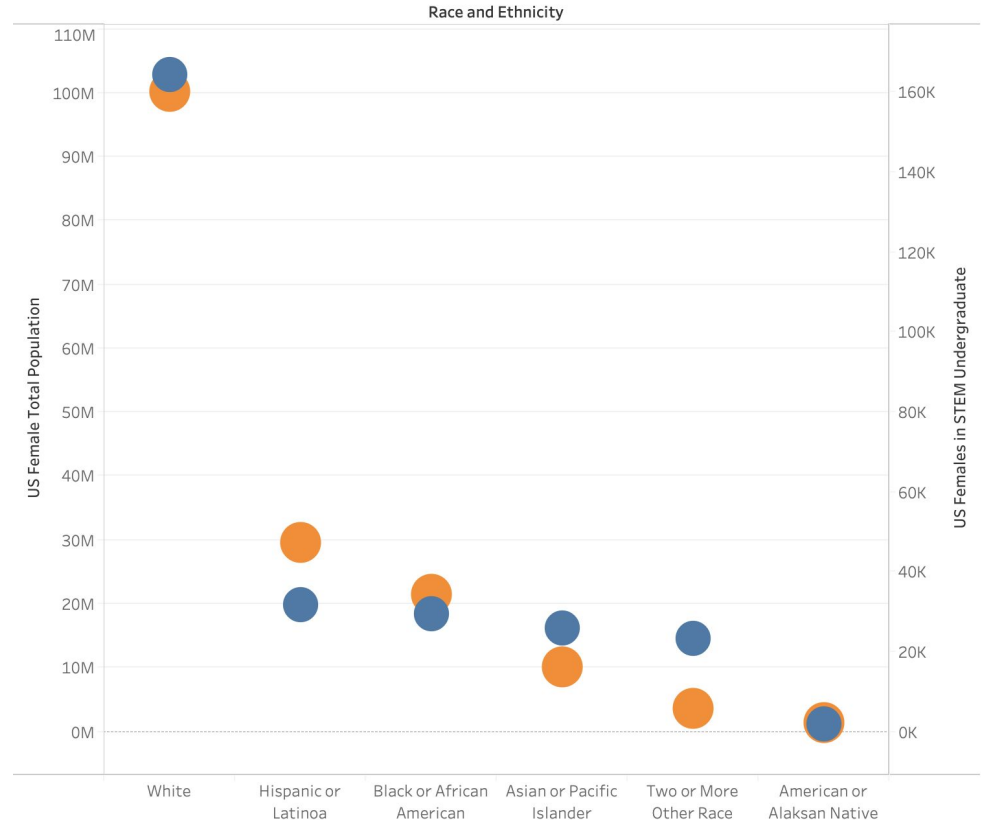- Graphed as scatter plot in Minitab and found 0.999 correlation

Earned STEM Bachelor's by Males vs. Females
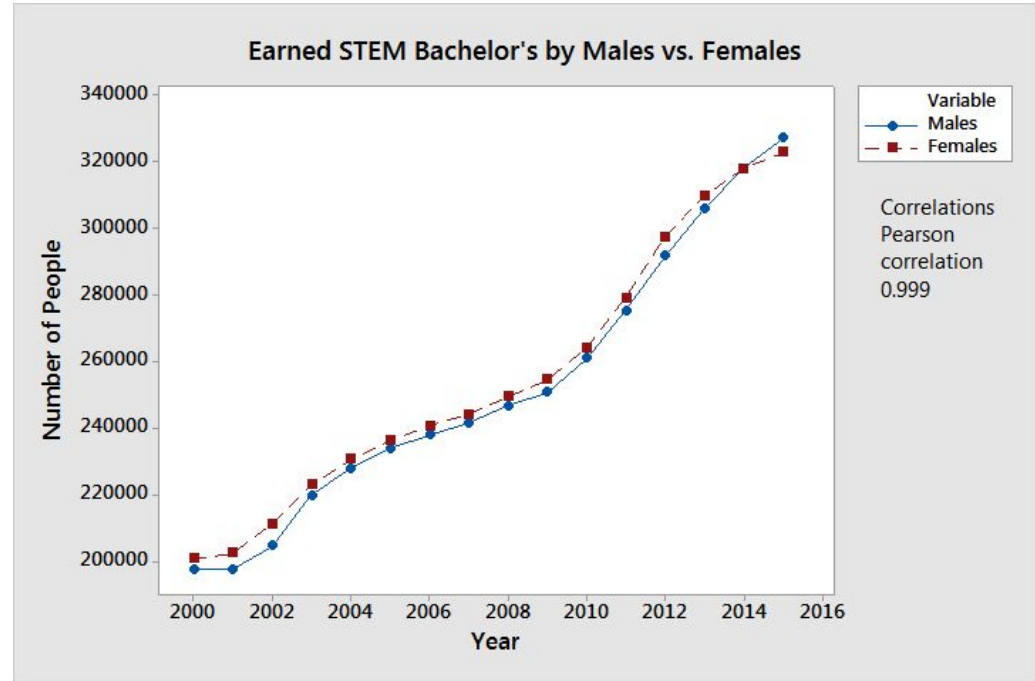
Query 4

- Based on average calculated STEM female undergraduates from 2006 to 2016

Average Ethnic and Race Distribution of Female STEM Undergraduates

Query 4 (cont.)

- Orange Dot: Total Female Population by Race and Ethnicity
- Blue Dot: STEM Majors by Female Undergraduates

- Correlation: 0.981

- Similar to Query 1, the ethnicity and race distribution among female STEM undergraduates follows the race distribution of the female population in US

Race and Ethnicity Distrubution Among US Female Undergraduate and US Female Total Population.

Sum of US Female Total Population and sum of US Females in STEM Undergraduate for each Race and Ethnicity.

Query 5

Average Number of Females with STEM Bachelor's per Major
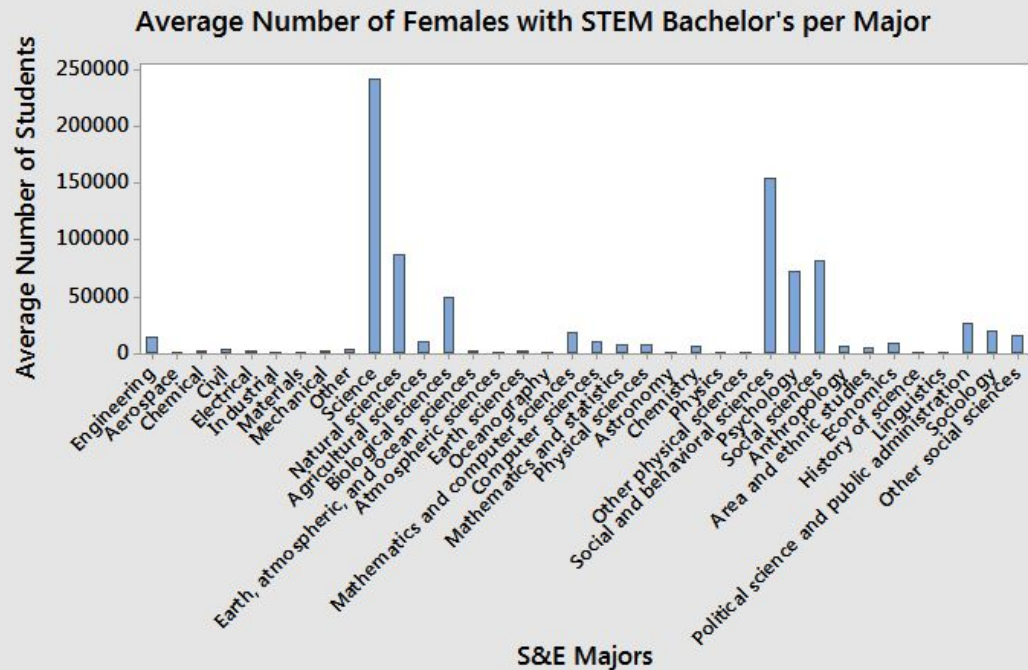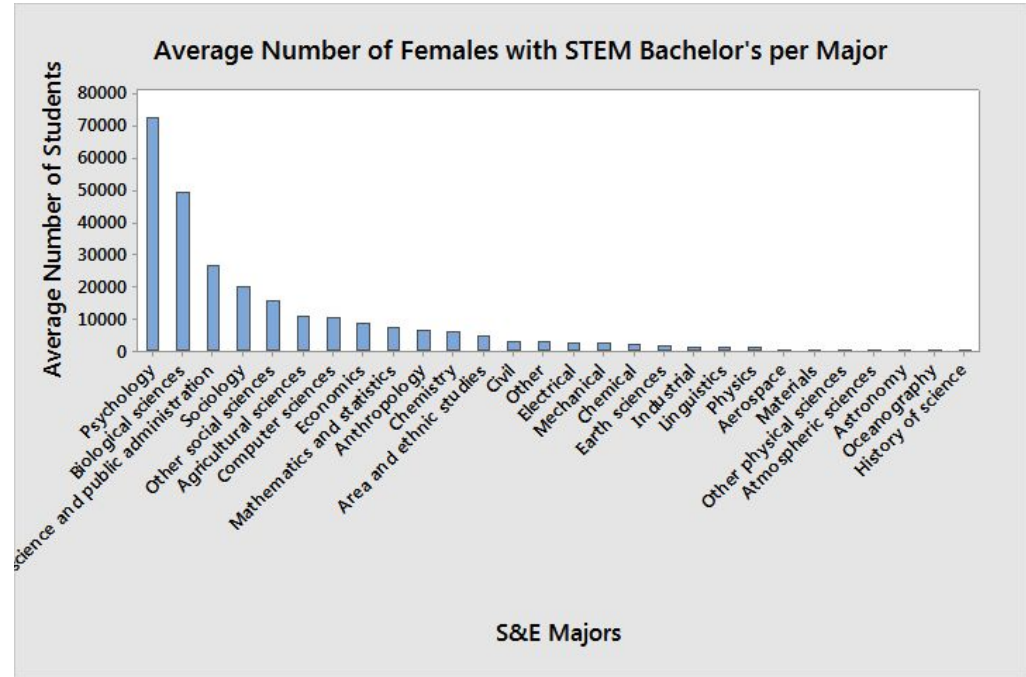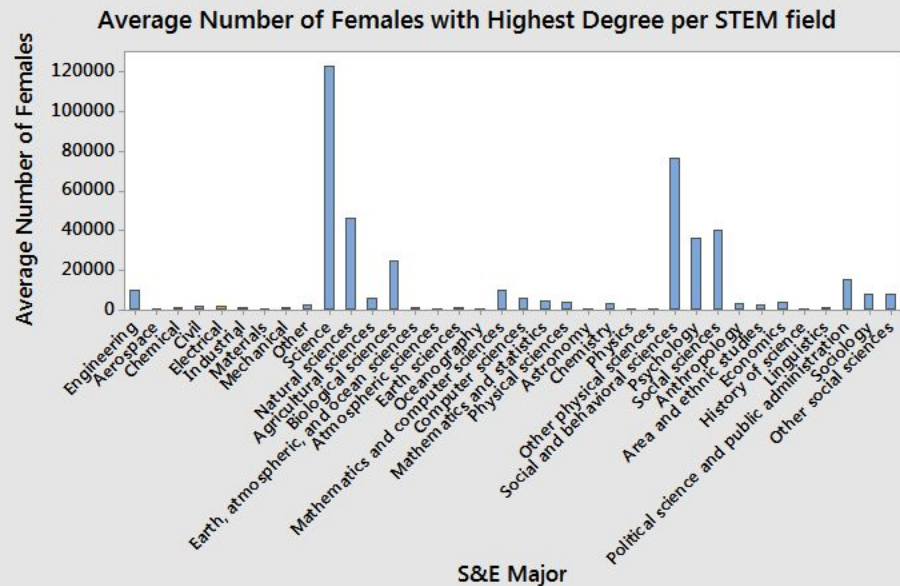
	A	B
1	S&E	Average
2	Engineering	14241.0625
3	Aerospace	420.8125
4	Chemical	2186.625
5	Civil	2789.375
6	Electrical	2310.4375
7	Industrial	1247.625
8	Materials	313.625
9	Mechanical	2212.0625
10	Other	2760.5
11	Science	241100.125
12	Natural sciences	86781.4375
13	Agricultural sciences	10731.4375
14	Biological sciences	49461.6875
15	Earth, atmospheric, and ocean sciences	1918.5
16	Atmospheric sciences	217.75
17	Earth sciences	1611.9375
18	Oceanography	88.8125
19	Mathematics and computer sciences	17517.3125
20	Computer sciences	10297.875
21	Mathematics and statistics	7219.4375
22	Physical sciences	7152.5
23	Astronomy	127.5625
24	Chemistry	5774
25	Physics	967.125
26	Other physical sciences	283.8125
27	Social and behavioral sciences	154318.6875
28	Psychology	72448.3125
29	Social sciences	81870.375
30	Anthropology	6207.125
31	Area and ethnic studies	4415.4375
32	Economics	8334.625
33	History of science	66.25
34	Linguistics	978.125
35	Political science and public administration	26589.4375
36	Sociology	19845.75
37	Other social sciences	15433.625

Query 5 (cont.)

- Originally calculated average number of females with STEM bachelor's for general and subcategories
  - Too cluttered
  - Results not accurate

- Afterward, removed broad categories (e.g., Engineering) to more accurately reflect results and actual majors
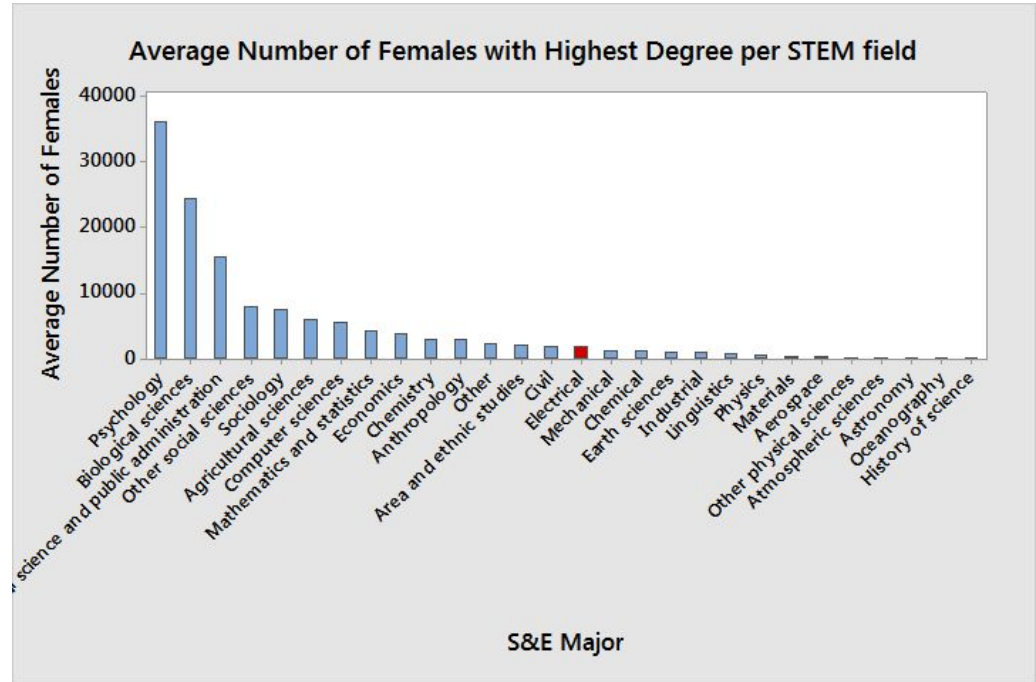

Average Number of Females with STEM Bachelor's per Major

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Query 6

Average Number of Females with Highest Degree per STEM field

| Sexandfield	Average			Max	Degree
Degree	Bachelor's	Master's	Doctorate		
Engineering	9,481	9,960	9,666	9,960	Master's
Aerospace	225.3125	236.8945313	224.2629395	236.8945313	Master's
Chemical	1156.0625	1,212	1143.0354	1211.503906	Master's
Civil	1812.4375	1,910	1,825	1910.339844	Master's
Electrical	1689.25	1,771	1,773	1772.825195	Doctorate
Industrial	918.875	972	960	971.8046875	Master's
Materials	294.25	302.265625	301.0947266	302.265625	Master's
Mechanical	1220.0625	1,289	1231.0354	1288.503906	Master's
Other	2164.4375	2,268	2,209	2267.527344	Master's
Science	116,489	122,862	114,012	122,862	Master's
Naturalsciences	44,185	46,329	43,414	46,329	Master's
Agriculturalsciences	5674.6875	6,001	5,635	6000.917969	Master's
Biologicalsciences	23,283	24,466	22,508	24,466	Master's
Earth,atmospheric,andoceansciences	1155.375	1,210	1155.118652	1209.523438	Master's
Atmosphericsciences	124.75	130.421875	125.0107422	130.421875	Master's
Earthsciences	948.625	995	947.3618164	995.1640625	Master's
Oceanography	82	83.9375	82.74609375	83.9375	Master's
Mathematicsandcomputersciences	9119.5625	9,639	9,276	9638.785156	Master's
Computersciences	5197.0625	5,501	5,363	5500.878906	Master's
Mathematicsandstatistics	3922.5	4,138	3,912	4137.90625	Master's
Physicalsciences	3,713	3,860	3,614	3,860	Master's
Astronomy	87.9375	89.62109375	86.72241211	89.62109375	Master's
Chemistry	2880.125	2,998	2,790	2998.007813	Master's
Physics	606.8125	626	602.2180176	625.6757813	Master's
Otherphysicalsciences	138.4375	146.4023438	134.9899902	146.4023438	Master's
Socialandbehavioralsciences	72,305	76,533	70,598	76,533	Master's
Psychology	34,173	36,151	33,524	36,151	Master's
Socialsciences	38,132	40,382	37,074	40,382	Master's
Anthropology	2812.5625	2,969	2715.267822	2968.722656	Master's
Areaandethnicstudies	1930.75	2,043	1,855	2043.234375	Master's
Economics	3686.5625	3,893	3,562	3893.222656	Master's
Historyofscience	33.875	35.1171875	32.43701172	35.1171875	Master's
Linguistics	656.9375	691	656.7966309	690.8085938	Master's
Politicalscienceandpublicadministration	14543.8125	15,416	14,456	15416.05078	Master's
Sociology	7043.0625	7,460	6,637	7459.628906	Master's
Othersocialsciences	7424.0625	7,875	7,159	7875.253906	Master's

Query 6 (cont.)

- Calculated and identified highest degree for general and subcategory majors

- Same problem as query 5, so removed general majors and sorted in descending order

Average Number of Females with Highest Degree per STEM field

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Hypothesis 1

- Created scatter plot comparing percent of women in STEM in northern US to southern US to determine the highest, mid, and lowest percentages

- Not useful since we could not correlate the point with the states
  - Tried to graph this plot with the state names, but it was too congested

Percent of Women in STEM Per State

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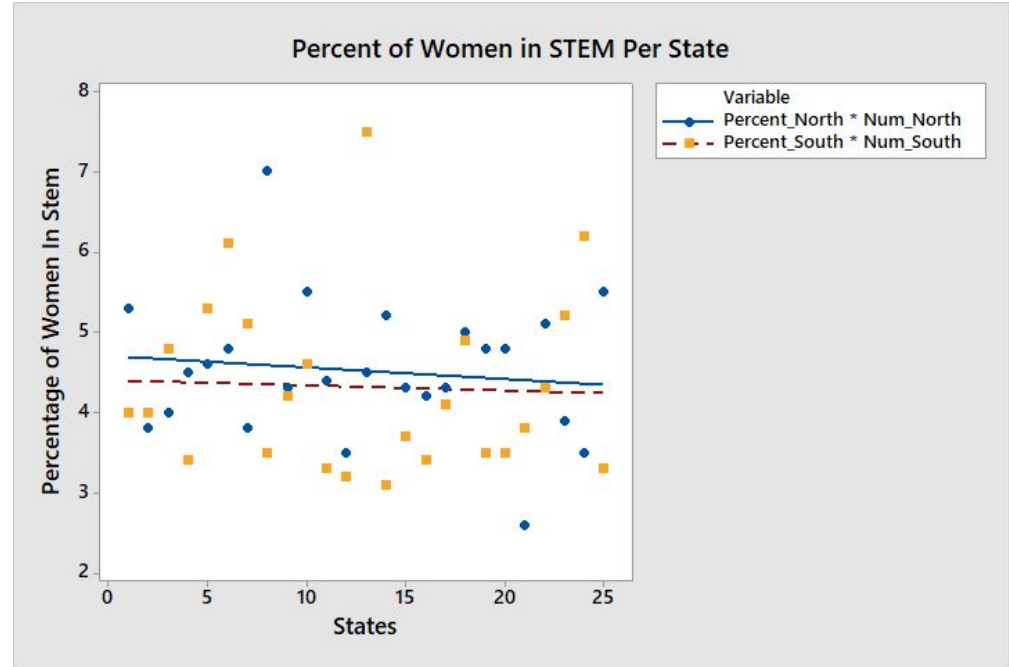
Hypothesis 1 (cont.)

- Used percent of ethnic minority women in STEM jobs per state as sample data

- Calculated sample mean and population standard deviation

- Two sample z test

- Failed to reject null hypothesis, so true average percent of women in STEM jobs in the North vs. the South is the same.

Hypothesis 2

- Used and calculated percent of ethnic minority women enrolled in STEM bachelor's degree programs per year as sample data

- Calculated sample mean and population standard deviation

- One sample z test

- Rejected null hypothesis, so true average percent of ethnic minority women awarded STEM bachelor's degrees in the US is greater than 30%

Hypothesis 2 Test

The average percent of ethnic minority women enrolled in STEM bachelor's degree programs is 30%.

$n = 11$, $\bar{x} = 38.59$, $\delta = 1.80$, $\alpha = .01$

Step 1: μ = true average percent of ethnic minority women awarded STEM bachelor's degrees in the US

Step 2: H_0: $\mu = 30$

Step 3: H_a: $\mu > 30$

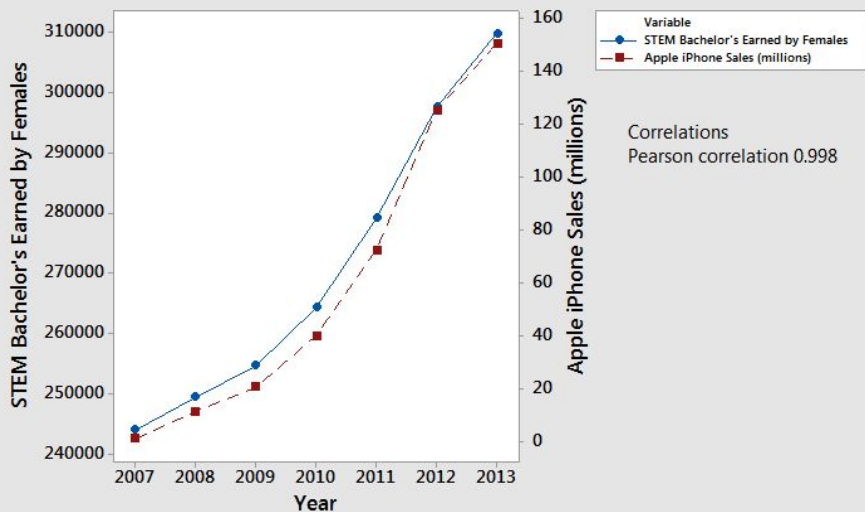Step 4: $z = \dfrac{\bar{x} - \mu_0}{\delta/\sqrt{n}} = \dfrac{\bar{x} - 30}{\delta/\sqrt{n}}$

Step 5: $n = 11$, $\bar{x} = 38.59$, $\delta = 1.80$

$z = \dfrac{38.59 - 30}{1.80/\sqrt{11}} = 15.83$

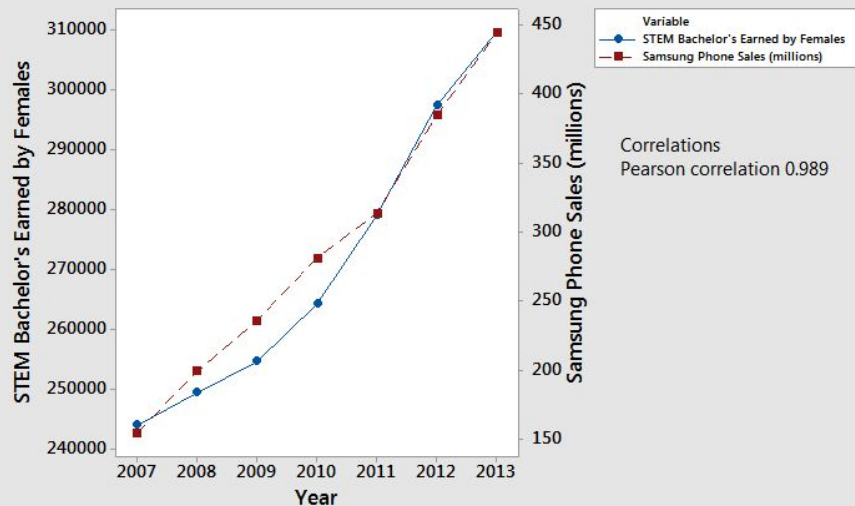Step 6: An upper-tailed test, so p-value = $1 - \phi(15.83) \approx 1-1 = 0$

Step 7: Because p-value $\approx 0 < .01 = \alpha$, H_0 is rejected. The true average percent of ethnic minority women awarded STEM bachelor's degrees in the US is greater than 30%.

Insight 1

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Insight 1 (cont.)

- Originally tried to graph all three data sets together, but scaling didn't show correlation well

- Resulted in graphing each phone sale separately with earned STEM bachelor's by females

Earned STEM Bachelor's, Apple iPhone and Samsung Phone Sales
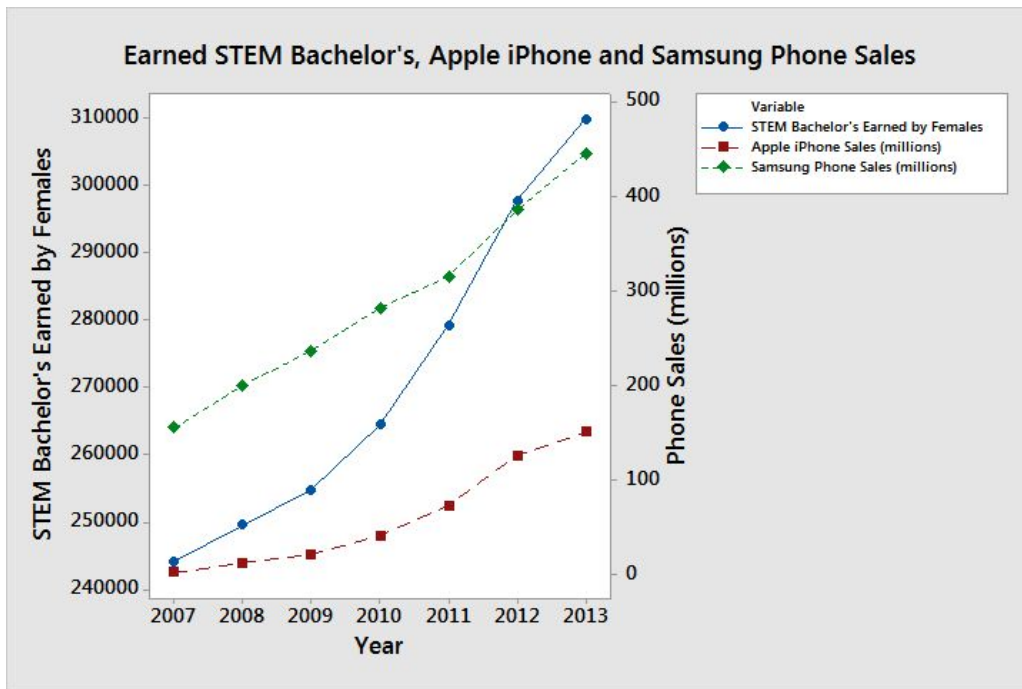
Insight 2

- Originally created a bivariate graph, which showed correlation between percent of women in STEM jobs and businesses per state
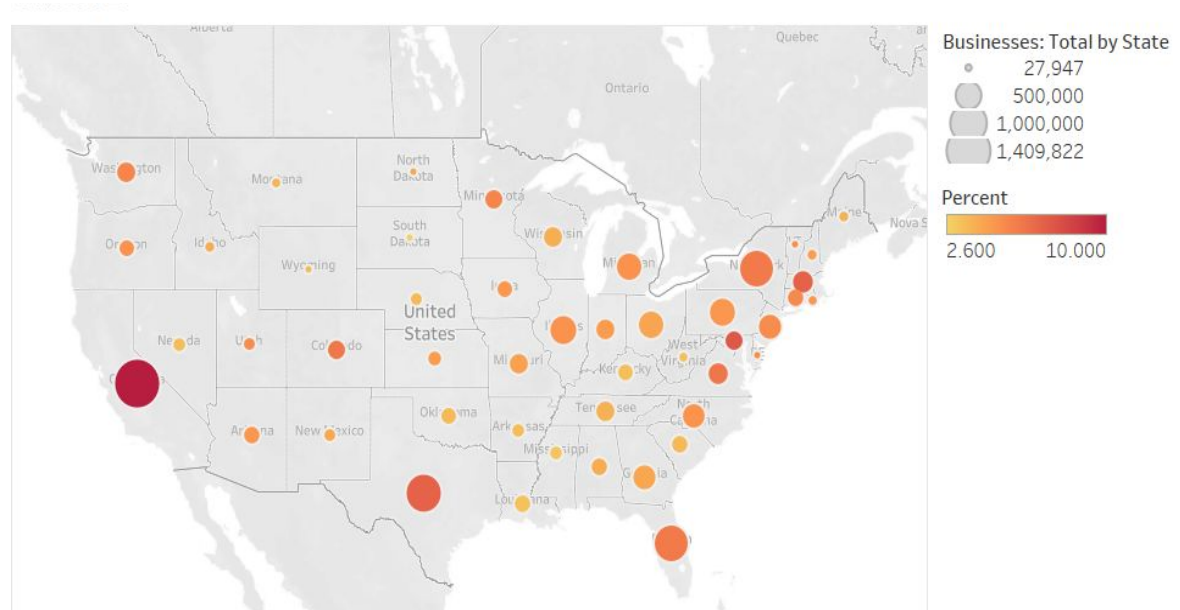
Insight 2 (cont.)

- This shows that a higher number of businesses correlates with a higher average household income and mid range of percent of women in STEM jobs. Lower number of businesses correlates with lower average household income and lower percent of women in STEM jobs.
  - Agrees with the map created using Tableau
  - Percent of women in STEM jobs is about the same in both the regions, which agrees with our hypothesis