Trend analysis of diversity in STEM in two Canadian universities

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Introduction

This analysis is to identify whether STEM field — science, technology, engineering and mathematics — are open to minorities of various sorts (gender, ethnic background) in University of Toronto and McGill University, by mining related authors by published papers, to see who is participating in STEM and explore how diverse these disciplines are according to three factors: population, race and gender.

Methods

The analysis extracts data by BeautifulSoup library, utilizes NamSor API v2 to analyze graduate students' gender (male or female) and likely race/ethnicity (W_NL (white, non latino), HL (hispano latino), A (asian, non latino), B_NL (black, non latino)), according to US Census taxonomy, and researchs relevant report and articles from the two universities, such as Figure & Facts from University of Toronto, Enrolment Report from McGill University, U of T News and McGill News. For visualizing results and validating findings, the analysis uses multiple graphs, as well as power analysis and two-proportion z-test to compare two observed proportions.

Data

All data is from McGill University and University of Toronto website. STEM is a curriculum based on the idea of educating students in four specific disciplines — science, technology, engineering and mathematics — in an interdisciplinary and applied approach. In this analysis, science includes chemistry, biology and physics, and technology includes computer science program in this research.

Analysis

1. Population

From the trend line of graduate students in STEM Majors in U of T from 2015 to 2019, we can see a sharp increase in 2016, both in Technology (computer science) and Science. In 2016, there's been a global recognition of Toronto's growing life sciences sector. For example, pharmaceutical giant Bayer and Versant Ventures inked a US$225-million joint venture to create BlueRock Therapeutics, co-headquartered in Toronto, which is an "engineered cell therapy company" that leans heavily on U of T research to create new therapies to treat heart and brain disease. The same year, health-care giant Johnson & Johnson launched its JLABS life science incubator at the MaRS Discovery District and, in 2015, U of T took steps to establish itself as a center of regenerative medicine with the help of a $114-million grant from the federal

government. What's more, other Canadian and multinational firms that have made similar pledges to launch or expand their Toronto operations in 2016– often with a connection to U of T – include: Facebook, RBC, LG, Bombardier, Thomson Reuters, Microsoft, Fujitsu and Intel.


Total number of students in STEM in UofT
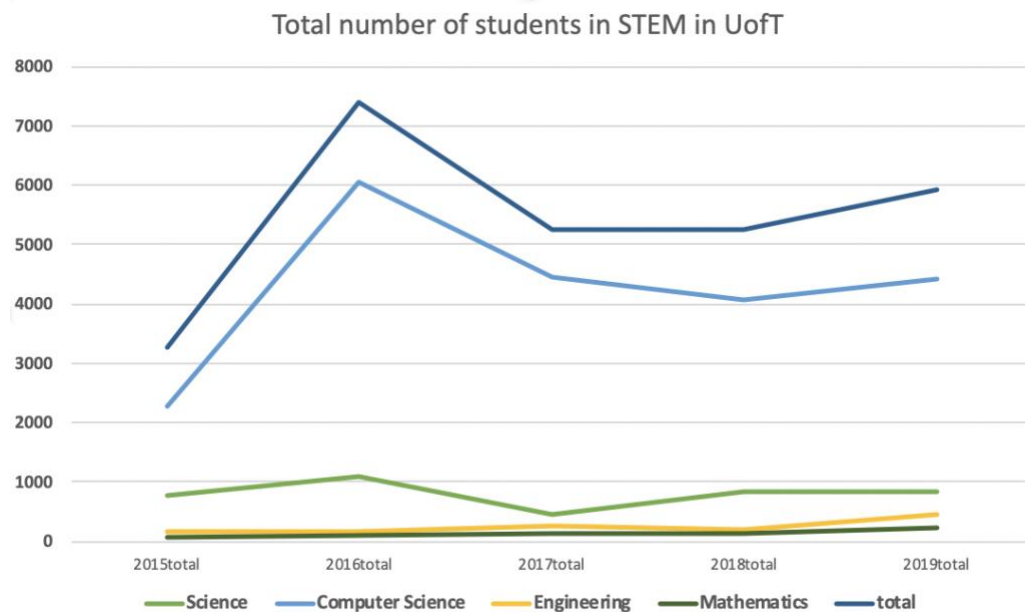
In McGill University, the number of graduate students is increasing generally. For testing whether the proportion of STEM in McGill is statistically different or not, conducted a power analysis and two-sample test for equality of proportion of STEM. The test result illustrates when significant level is 0.01, and the 2.64 z-score from the two-sample test shows that we have significant evidence to reject null hypothesis, which means that the proportion of STEM graduate increase statistically. Therefore, the percentage of students in STEM is increasing from 24.4% to 27.3%, which means STEM is becoming more popular from 2015 to 2019.

Total graduate students in STEM in McGill

PERCENTAGE OF STEM IN MCGILL
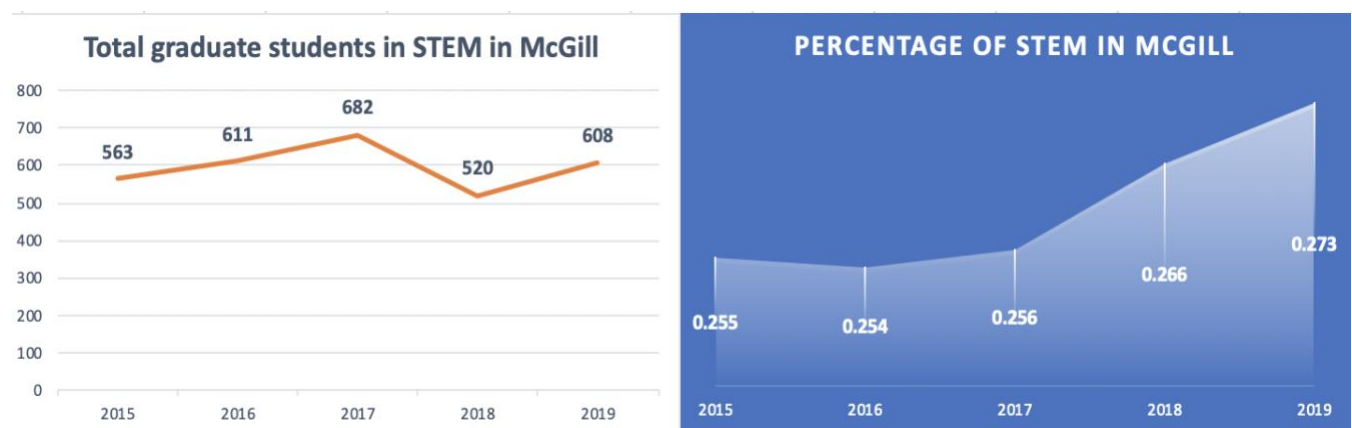
Overall, the number of graduates in STEM is increasing in these two universities, and there are more and more students who engage in STEM research nowadays.

2. Gender

In McGill University and University of Toronto, there are more females than males among all graduate students from 2015 to 2019, while in STEM Majors, there are more males than female. In U of T, the average female ratio in STEM is increasing.
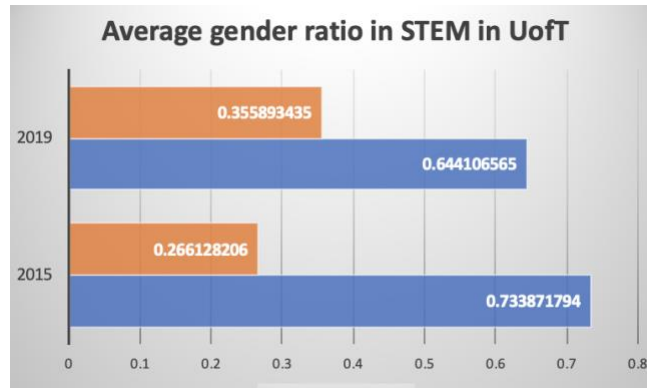

More specifically, the percentage of female in Computer Science and Engineering almost share the same increasing trend, and the percentage of female in Science increase dramatically from 2016. The achievement is one reflection of the Faculty of Applied Science & Engineering's broad commitment to enriching diversity. Driving that diversification in U of T Engineering are events such as the Girls Leadership Experience in Engineering (GLEE) and the Young Women in Engineering Symposium (YWIES), which inspire girls as they learn more about the impact they can make as engineers, in fields from sustainable energy to health care.
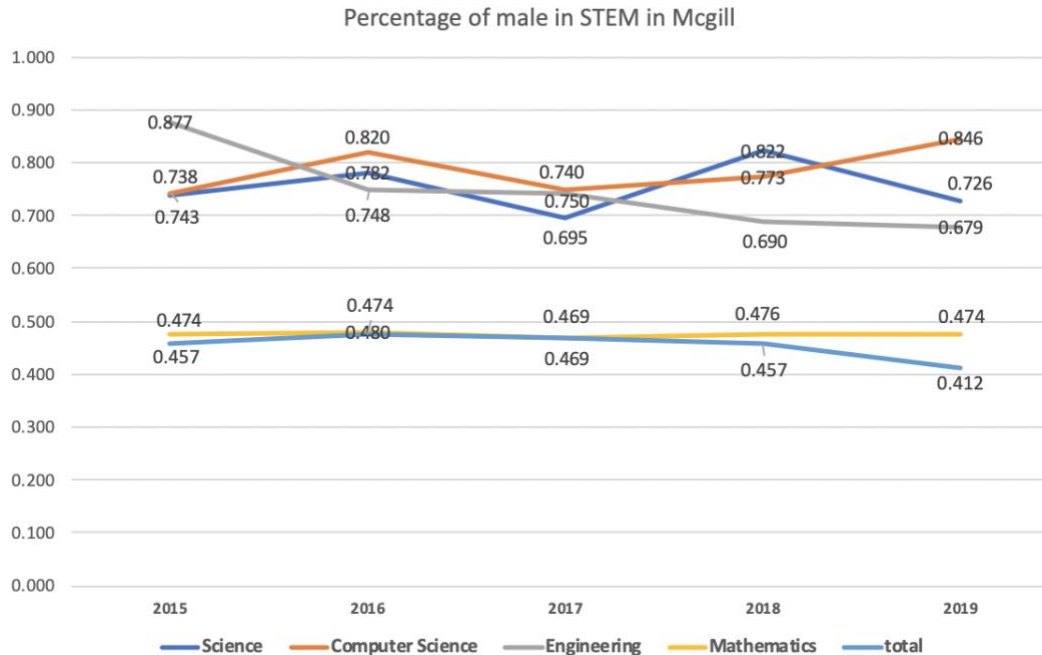
What's more, U of T is always working on boost presence for women, for example, one of U of T events where attendees at a U of T Wikipedia edit-a-thon are encouraged to create Wikipedia entries for women in STEM, because one graduate student in STEM at the U of T found that only 20 per cent biographies are about women and 90 per cent of editors are male. Therefore, the gender gap in graduates is closing, but still not enough. In 2020, a study surveyed 279 undergraduate and graduate students at U of T Engineering who were studying machine learning/AI – 38 per cent identified as female, 61 per cent identified as male.
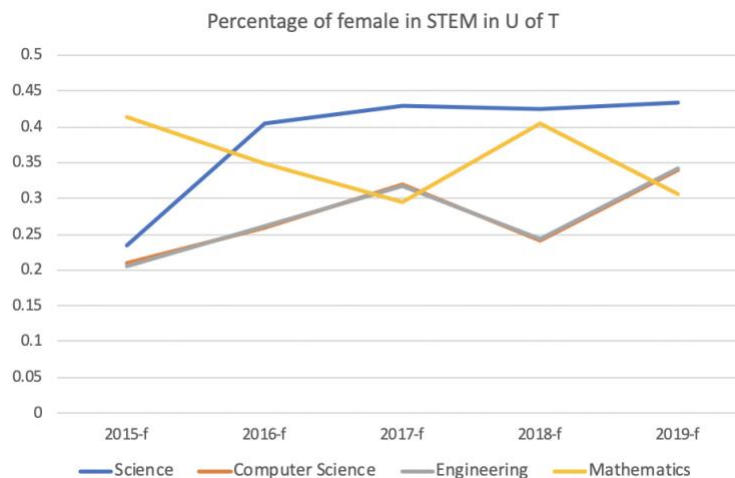
In McGill University, the percentage of female in the Engineering is increasing, while the percentage of female in the Computer Science is decreasing. From the two-proportion z-test result of proportion of female in Science, the z-score is -0.1664536, which means we don't have enough statistically evidence to reject null hypothesis and indicates that the percentage of female in Science stayed unchanged from 2015 to 2019. One of McGill researchers found that, the time commitment of doing postgraduate studies may be a big drawback for women, and the relatively low number of those going on to graduate studies will ultimately have an impact on the supply of professors. Even when women do postgraduate studies, it is exceedingly difficult to retain them as professors because of the attraction of enormously well-paying public service jobs. The Faculty can recruit women, but because governments are under the same kind of pressure to meet gender equity as universities, McGill loses women faster than they can be lured in. In order to compensate for this trend, some faculties have, since 1984, run mentorship programs to encourage female students to pursue postgraduate degrees. A number of the women who have gone through this program have gone on to become professors, and even deans of other schools.

Percentage of female in STEM in Mcgill
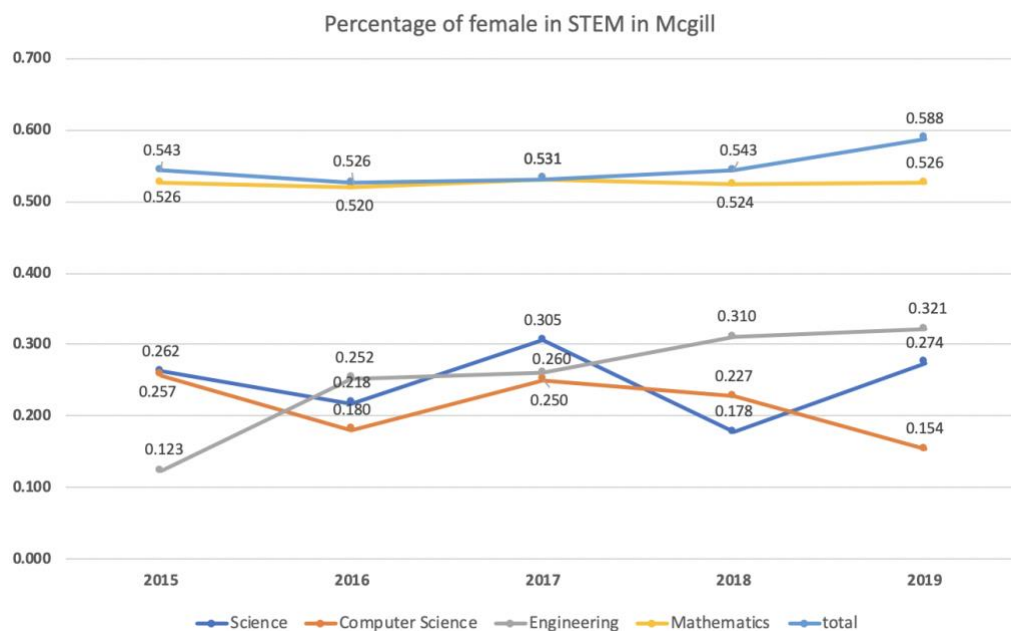
Interestingly, men are actually a minority at McGill from the perspective of all graduates, and their numbers are slowly dwindling, although males still dominate in STEM. However, McGill is now trying to find why there a decreasing participation of males. Nick De Takacsy, Associate Provost of Academic Services and the chair of the University Admissions Committee (UAC), reported that he doesn't believe there is any structural discrimination against males in the process that would account for the current trend. Director of Admissions Kim Bartlett said that admission to McGill is strictly merit-based, "In a nutshell, McGill admission is based on your grades, and we don't much care where you come from, what you look like, what your religion is, what color you are, or what gender you are."

Percentage of male in STEM in Mcgill

Legend: Science, Computer Science, Engineering, Mathematics, total

"STEM has the potential to significantly shape future technologies, which only underscores the need to increase the diversity of workers within the field. If people don't see a change, then biased teaching, inputs, algorithms, applications and decisions will lead to further discriminatory and negative social consequences", one researcher in STEM at the U of T said.

Gender dynamics at university are fluid and complex, each university are making effort to extend the quality and impact of their academic, research and teaching programs, and to build the diversity of their communities in service of the excellence, and both universities are becoming more diverse on gender.

3. Race

In U of T, from the trend of average race ratio in U of T, Asian and White are taking the dominant part among graduates in STEM. And the percentage of Asian is increasing, which is heavily associated with Asian country focusing much more on developing Technology from 2016. According to U of T Fact& Figures, international graduates from Asia & Pacific has increased to 61.3% in 2019 from 57.9% in 2015, among which, graduates from China has increased to 39% from 34.1% in the 5-year period. Although there is a similar increasing trend of the increasing percentage of Black graduate in STEM, but it really depends on which discipline they at.

Trend of average race ratio in U of T
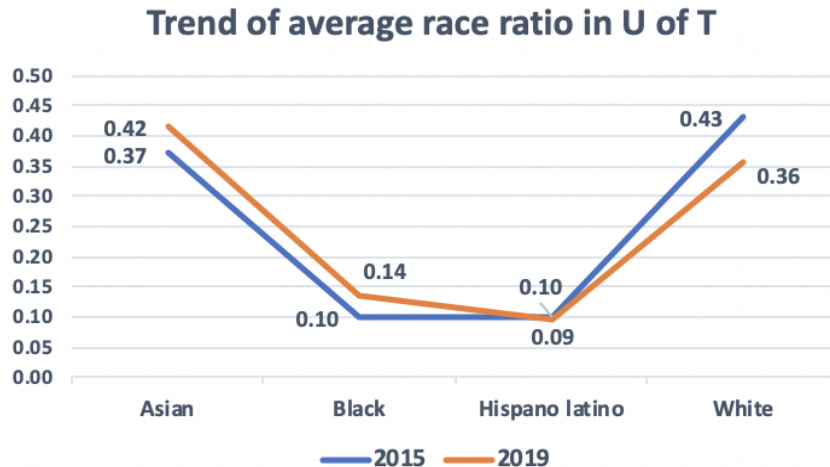
In McGill University, the trend line of average race ratio in STEM is becoming flatten in 2019, compared with a distinct bottom point in 2015, which Hispano Latino only take 6% part of all STEM graduate in 2015. Asian and White always composite the main part of graduates from 2015 to 2019.


Trend of average race ratio in McGill
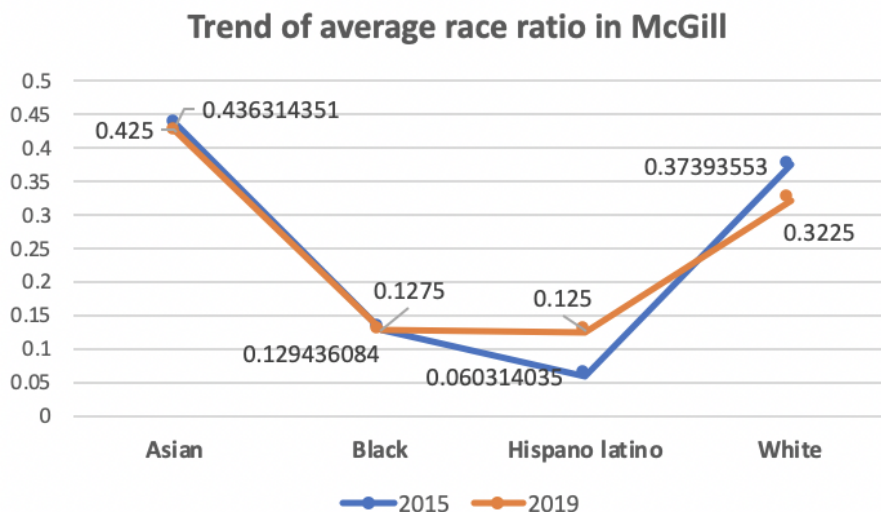
Specifically, the race gap in STEM graduate in U of T is closing in Science, Engineering and Mathematics, while the graduate in Computer Science shows a larger difference between each ethnicity group.

Generally speaking, Asian remains a large part in graduates in Computer Science. However, in U of T, the number of black and hispano latino is decreasing. There is still a severe lack of representation of Black and Indigenous students, found by a study on students pursuing and persisting in machine learning/AI studies at U of T Engineering. The study also found that, of the 279 students surveyed, only two per cent self-identified as Black and zero per cent as Indigenous, which was shown to be the case in a sample size where 84 per cent of students self-identified as a visible minority. "So even when visible minorities are significantly represented,

representation of Black and Indigenous students does not necessarily follow. There needs to be future work that focuses on the unique experiences and predictors of Black students that can elaborate further", the researcher at U of T says.

In Engineering field, it is noticeable that in 2016 there is a sudden increase on Asian graduate in McGill, and consistently accounted almost half of graduates in STEM these 5 years. Similarly, Asian in Engineering accounted nearly 45% through these years in U of T. While the percentage of black, non_latino and hispano latino remains low with slowly increasing trend, and White in Engineering are decreasing in both two universities.
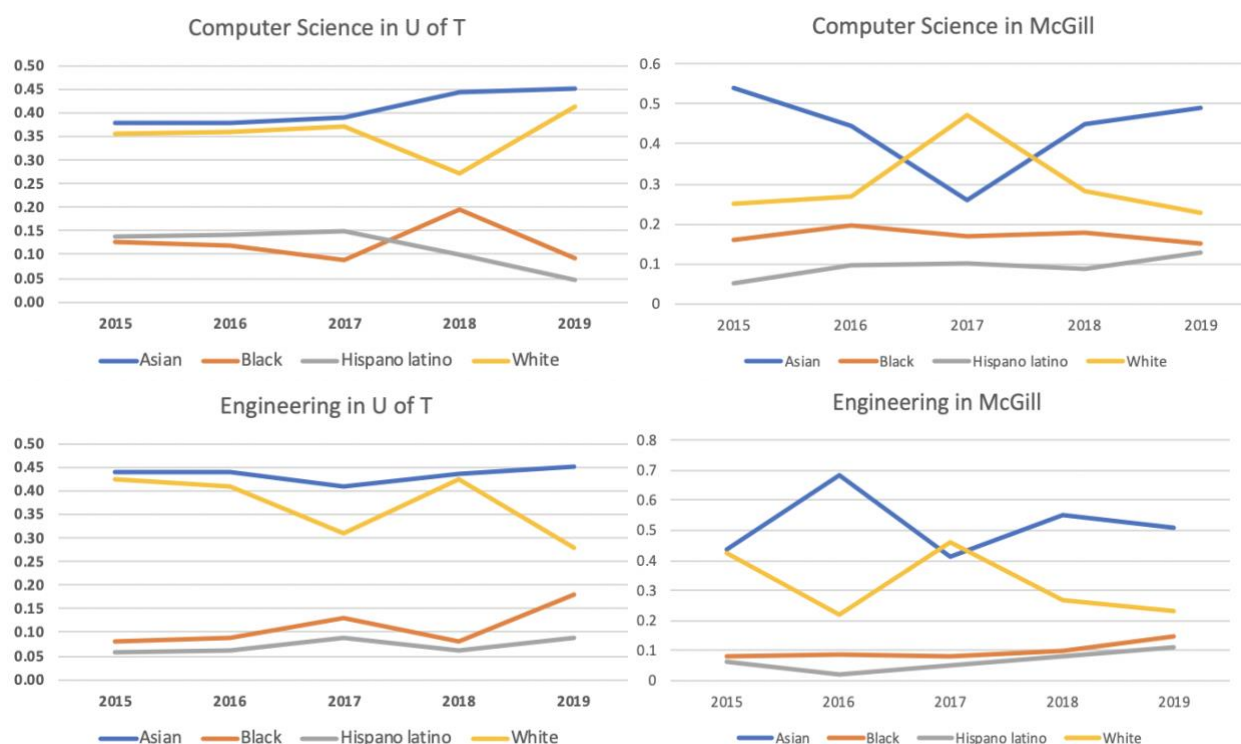
The situation is a little different in Science and Mathematics graduates. White is taking majority spaces from 2015 to 2019, while Asian and Black, non_latino is gradually increasing. The number of Hispano latino is almost the lowest part in Science and Mathematics in both universities. According to the 2016 Canada Census, visible minority group accounts for 22.3% of the total population, including Chinese, Black, South Asian, Latin American and etc., and tthere is 79.2% White in Canada. Since both universities are in Canada, considering with the appropriate percentage of university enrollment on both domestic and international students, the data is fair and both universities are becoming more diverse on ethnicity.

Science in U of T

Science in McGill

Mathematics in U of T

Mathematics in McGill
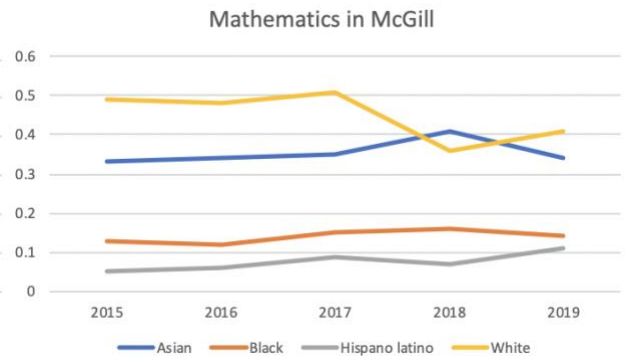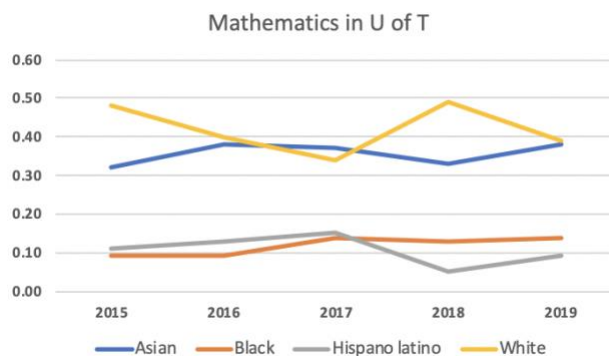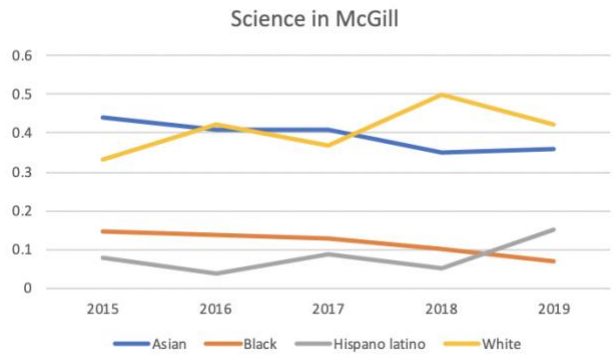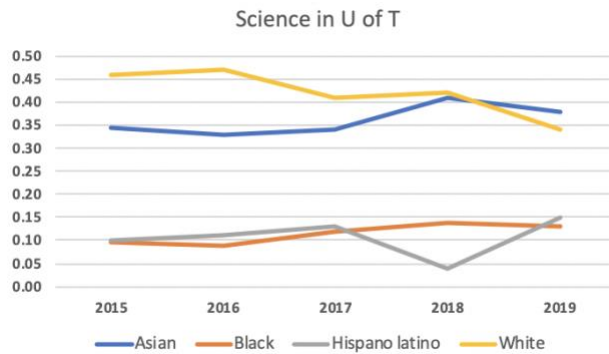
"Diversity accelerates innovation, enhances the student experience and enriches the profession with different perspectives and ideas," said Dean Cristina Amon from U of T. "In the Faculty of Applied Science & Engineering, we are deeply invested in advancing diversity and fostering inclusivity within Engineering and beyond. These numbers show our tremendous progress, but there remains work to be done."

The good news is, there are more and more people and researchers paying more attention on diversity of workers within STEM field. In a study led by University of Toronto alumna Kimberly Ren, it provides recommendations to eliminate gender/race discrimination in engineering education, including mandatory anti-discrimination training modules, as well as accessible and transparent reporting of discriminatory behaviour that would affect faculty/teaching staff promotion and progress reporting.

Overall, in terms of diversity in STEM in University of Toronto and McGill University, thanks to various events, diversified enrolment standard and different studies by researchers on how to make STEM more diverse, those two universities are doing better on diversity of population, gender and ethnicity.

Appendix
```r
library(pwr)
pwr.2p2n.test(h = 0.2, n1 = 563, n2 = 608, sig.level = NULL, power = 0.8)
```

```
##
##      difference of proportion power calculation for binomial distribution
(arcsine transformation)
##
##               h = 0.2
##              n1 = 563
##              n2 = 608
##       sig.level = 0.009966698
##           power = 0.8
##     alternative = two.sided
##
## NOTE: different sample sizes
```

```r
prop.test(x = c(2028,2401), n = c(7956,8794), alternative = "less",conf.level
 = 0.99)
```

```
##
##  2-sample test for equality of proportions with continuity correction
##
## data:  c(2028, 2401) out of c(7956, 8794)
## X-squared = 6.9623, df = 1, p-value = 0.004162
## alternative hypothesis: less
## 99 percent confidence interval:
##  -1.000000000 -0.002151639
## sample estimates:
##    prop 1    prop 2
## 0.2549020 0.2730271
```

```r
qnorm(0.9958)
```

```
## [1] 2.635554
```

```r
prop.test(x = c(62,43), n = c(236,156), alternative = "less",conf.level = 0.9
9)
```
```
##  2-sample test for equality of proportions with continuity correction
##
## data:  c(62, 43) out of c(236, 156)
## X-squared = 0.027701, df = 1, p-value = 0.4339
## alternative hypothesis: less
## 99 percent confidence interval:
##  -1.00000000  0.09901726
## sample estimates:
##    prop 1    prop 2
## 0.2627119 0.2756410
```

```r
qnorm(0.4339)
```

```
## [1] -0.1664536
```