



Physical & Environmental Sciences
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Sustainability Research Project

**An Investigation of the Decrease in Enrollment Number of
Chemistry/Biological Chemistry Specialist Programs in UTSC**

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Abstract

Chemistry specialist programs at the University of Toronto Scarborough (UTSC) had a decline in enrollment numbers for the past ten years. University of Toronto Scarborough Department of Physical and Environmental Science department (DPES) offers chemistry specialist, biological chemistry, and environmental chemistry specialist as specialist options for students. Sustainability of specialist programs is unsuccessful, students in DPES give high preference to major options. The issue was reported to students by Professor Effie Sauer in late 2019 and a survey was issued to students to determine why the major option is a preference. By collaborating with the office of registrar and Professor Effie Sauer, our team was able to get the past enrollment data for the past ten years as well as student feedback from students in DPES. Regarding the survey, course selection is the primary reason why a student chooses the major option. DPES only offers two introductory chemistry courses for students who are first-year, which lacks a decent introduction to the world of chemistry to new students. In biological chemistry, there are only three true biochemistry courses out of the twenty-nine requirement courses, leading to more off-topic courses for students to take. The lack of chemistry courses offered by DPES is the ultimate problem we propose. St. George campus offers more specialist programs with a focus on each discipline of chemistry, this is something UTSC DPES should focus on.

Key Words

DPES, Education, Chemistry, University, UTSC

Introduction

Sustainability has many definitions and concepts, one of which is the ability to maintain at a certain level which could be either economically, environmentally or socially. Most post-secondary institutions are increasingly involved in branding activities and active on social media networking platforms to promote their programs and sustain their position in the competitive postsecondary education market (Bélanger, Bali, & Longden, 2014). A study has also shown that emotional factors also influence students' choices on their post-secondary institutions, for instance the school could be their “dream” school due to famous and wealthy alumni, a Co-operative program for their interested field of study is offered, it has an attractive campus, or even for the smaller class sizes etc (Steele, 2008).

Over the past years, the University of Toronto Scarborough consistently promotes and accepts more students each year. According to the data shown on Common University Data Ontario (CUDO) on the University of Toronto Website, the total enrollments for each undergraduate

program are increasing. However, in October 2019, an email was sent by Dr. Effie Sauer, an associate professor of the Department of Physical Science and Environmental Science Department, who stated that the department is conducting a review on what drives students to choose major programs instead of specialist programs. The programs offered in the Department of Physical and Environmental Science are divided into three major categories including environmental science, physics, and chemistry. All programs are shown in table 1. In the email, Professor Effie also issued a survey regarding the decreased enrollment in the specialist program, particularly in the Biological Chemistry and Chemistry specialist programs. Past research has also stated that between 2006 to 2016 there is a potential increase of 9 -18% of the total full-time students in University (Trends in higher education, 2020). But based on the data shown on CUDO on the University of Toronto Website, the total enrollment for science-related programs was experiencing an increase between 2009 to 2015 but slightly decreased between 2015-2017 as shown in Table 2. Although the University of Toronto Scarborough (UTSC) has been consistently promoting its programs and campus, the decrease in enrollment number reflects matters regarding the sustainability level of the Department enrollment. Particularly over the past years, there is a dramatic decline of enrollment numbers in Chemistry specialist and Biological Specialist programs, as students give preference to major programs instead of specialist programs.

Metadata of graduation and employment rate on the University of Toronto website have also shown that the graduation and employment rates of Physical science programs are much lower than the other undergraduate programs. Research has shown that the required skill during higher education studies often affects the employability as employers value these skills more (Osmani, Weerakkody, Hindi, & Al, 2015). The skills, experiences, and knowledge that students gain in their undergraduate study will potentially influence their capability to handle tasks assigned by their employees in the future. With well-developed specialist programs, students are likely to be more successful in graduate school application and job application, because the specialist program allows students to gain more knowledge and experiences in a specific area of interest. Students enrolled in specialist programs also have the chance to explore more state-of-the-art softwares and machines that are used in the area of study because there are much more requirements for the courses than the major programs.

Fewer students enrolled in the specialist programs will strongly affect the sustainability of the institution at the Department because there will be an increase in the possibility of removing the program in the future. The purpose of this project is to understand and analyze how sustainability of Education and Awareness is done at UTSC, particularly in the Department of Physical and Environmental Science under the branch of Student enrollment per faculty/department. This research aims to analyze the current problems associated with the declining enrollment situation and try to find possible future recommendations to improve the sustainability level in the Department.

Methodology

In Professor Effie Sauer's email, her purpose was to understand why students avoid specialist programs. Statistics about the students' year of study, program of choice, and other objective questions were asked. The courses the students want to avoid by taking the major instead of a specialist and whether the students believe the major programs prepare them for graduate school were the core questions. The acquisition of the survey results provided an understanding of the students' current standpoint on the programs. Professor Effie Sauer also collaborated with Mari Motrich, the manager of system and data analysis at the office of the registrar, to obtain the past 10 years' program enrollment.

The students who completed the survey were divided into two general groups: 1st-year students and upper-year students. First-year students were new to the university and tended to worry more about program selection, they placed more value on the list of courses, co-op opportunities, and program requirements. Metadata such as a list of programs, a list of courses, and program requirements were collected for comparison of each program. Upper year students were more concerned about future job opportunities, job demand, job market, graduate studies, and as well as program completion. Metadata such as the job market/job demand, current Master/Ph.D. programs, and average starting salary of different degrees of education were more important to them. These factors may have influenced students' choices as students also tended to switch out from physical and environmental sciences to other programs that have better job markets such as computer science, statistics, and engineering. Therefore, we also obtained the possible job positions of these popular programs and their starting salary for comparison and job demand. The types of metadata collected for this project were summarized in table 3.

The specialist program required specific courses and it demanded more credits to graduate than the majors. In a full evaluation of the list of specialist courses, this research correlated with survey comments for the investigation of the problem with course offerings at UTSC. Enrollment data from the UTSC registrar shows a clear decline in trend for the previous ten years.

Results

The past enrollment data obtained comprises both specialist and major program enrollment numbers for the past 10 years. As illustrated in Figure 1, the graph consists of a decreasing trend in the specialist programs' enrollment and the highest total enrollment that occurred in 2010. The biological chemistry specialist program has the highest enrollment number of 129 in 2010 and the lowest enrollment number of 6 in 2019. The chemistry specialist program had consistent low enrollment numbers for the past 10 years, there is no dramatic decrease in the data with an average of around 15 students each year. The enrollment in the Environmental chemistry specialist program was increasing during 2013 -2017 and decreased after 2017. Figure 2 shows the past enrollment data for the biochemistry majors and chemistry major

programs. The number of students enrolled in major programs has an average of around 500 each year with a recent highest peak of students enrolled in 2016. Similar to chemistry specialists, chemistry majors had a fairly steady low enrollment number. More students are enrolled in the biochemistry program. The ratio between the specialist programs and major programs is only 1:6.

In total there were 125 students that completed the survey, and they are students in both biological chemistry and chemistry programs. As shown in Figure 3, out of the 125 students 16% of them are planning to graduate with a specialist degree. In Figure 4, students who completed the survey are divided into first-year students which represent 7% of the total students and upper-year students which represents 93% of the students. Figure 5 shows that out of the 93% of the upper-year students who completed the survey, most of them believe completing the majors would adequately prepare them for graduate studies and job preparations.

Figure 6 shows the courses students want to avoid by taking the major instead of specialist. Out of the 102 biochemistry students who completed the survey, 72 of them wanted to avoid the first-year physical course. 27 wanted to avoid third-year inorganic chemistry and organic chemistry courses. Out of the 22 chemistry students who completed the survey, 11 of them wanted to avoid second-year calculus courses, 9 of them wanted to avoid third-year biophysical courses, and 8 of them wanted to avoid third-year inorganic chemistry courses. Figure 7 shows the introduction courses offered in the first year for all three programs in the Department of Physical and Environmental Science. Figure 8 shows the list of courses required for degree completion for the biological chemistry specialist. The courses covered in the chemistry specialist program are shown in figure 9 which includes organic chemistry, inorganic chemistry, theoretical chemistry, analytical chemistry, biological chemistry, and environmental chemistry. The biology and chemistry related programs offered by U of T three campuses are listed in Figure 10.

Discussion

Although the survey results and most of the past enrollment data were obtained with the help of Dr. Effie Sauer, there were still a few challenges encountered. Firstly, the data obtained was less than expected. The request of the data included the enrollment and graduation numbers for all the programs in the physical and environmental science department, however only some of it was shared. Also, there is no degree completion rate for UTSC listed in the common university data Ontario on the University of Toronto website. Lastly, only 125 students completed the survey, which was less than expected. The challenges for obtaining the data limits the data analysis of this research as it becomes more conceptual and subjective analysis. The programs offered by the Department of Physical and Environmental Science includes biological chemistry, chemistry and environmental science, due to the limitation on the data obtained for

environmental science, the research is also limited to analyzing the sustainability of biological chemistry and chemistry programs.

The two pie graphs in Figure 3, show that a large portion of students do not prefer the specialist program as the ratio between the specialist program and the major programs for chemistry and biochemistry is only 1:6. This ratio is extreme to the point that if the enrollment of the biological chemistry and chemistry program continues to decrease, the program will no longer be offered in the future. From the current data obtained, there are a few possible reasons for the decline in enrollments. Judging by the survey conducted by Dr. Effie Sauer, many students choose the major option due to course selection. "We do the exact same courses; the difference is very slight". A large majority of the comments revolve around this idea. When it comes to program selection, students' choices tend to be influenced by the courses that are required for degree completion and this level of influence sometimes even overshadows their passion. Avoiding courses is currently the primary reason why students prefer the major program instead of the specialist program. From the survey data shown in Figure 7, math and physics are the top courses students are actively trying to avoid in their first year as these two courses have a reputation of low course average and are hard to pass. Students also tend to avoid courses that consist of long hours of lab work such as third-year inorganic and organic chemistry. In addition, the survey also indicates that students strongly believe a major option will suffice their career goals (such as jobs and graduate school). These findings ultimately lead to more research on the question of why students think this way.

As shown in Figure 8, in both biochemistry and chemistry specialist programs, students start off their first year with very few introductory chemistry courses related to the specialist topic. The specialized courses begin in the second year. Over the course of eight months, this lack of related courses can really take away students' interest as the introductory courses cover the topics which are previously learned in high school. On the contrary, there are a total of six A level courses in environmental science here at UTSC. Having more introductory courses not only introduces the programs' subjects quickly, but it can also make chemistry more attractive since it will give other students from other disciplines an opportunity to try out chemistry as well.

Another problem seen with the specialist programs is that many of the courses are off-topic. Taking the biological chemistry specialist as an example, in order to complete the specialist degree, students will need to complete a total of 14.5 credits. However, there are only three courses which are purely focused on biological chemistry: BIOC12, BIOC13, and BIOC23. Furthermore, the three courses are only offered as third-year courses. While there are many courses that serve an interdisciplinary purpose, overall, there are just too few pure biological chemistry courses. Meanwhile, students are required to spend a massive amount of time in other disciplines of chemistry like inorganic chemistry, theoretical chemistry, and analytical chemistry, therefore students would think choosing a major program option will minimize the ratio between true biological chemistry courses and filler courses. Furthermore, in 4th-year chemistry courses, all courses disuse cutting edge technology of today's world with a high emphasis on discussion. This is not the case for the first three years of study for a specialist

student, a large majority of the courses consist of the following format: lecture + lab + exam. The department should consider offering discussion-based courses in earlier years for a specialist student. This is to let students develop their own interest in the field. Examples of those introductory discussion-based courses are EESC34 and PSCD11. Through discussion, students can really take their time to cultivate their own opinion along with a professor.

Figure 9 shows the courses covered in the chemistry specialist program. The courses cover all disciplines in chemistry very evenly. The big problem is that students usually prefer one field more than the other, which may be the reason why students prefer biochemistry over chemistry. When looking at Figure 10, UTSG offers many more chemistry specialists with more focus in each discipline. The additional UTSG specialist programs include chemical physics specialist, material specialist, and pharmaceutical specialist. Out of the three campuses, UTSC has the least chemistry-related programs. To create these programs, the department will need to create more chemistry courses. A large problem with the department is the lack of chemistry courses, this ultimately gives the specialist programs a poor sense of identity. Having an attractive and specific field of specialist titles will motivate more students to give difficult specialist programs a chance.

Moreover, the students who complete the survey are grouped into first-year students and upper-year students. 1st-year students are more concerned about choosing the right program for their degree, therefore they value more about the list of courses, the program requirement, and whether the program combination fits what they want to do in the future. Upper year students who already decided their program will put more value in their future paths such as possible job opportunities and future academic pathways. The majority of the students think that completing the majors will adequately prepare them for graduate studies and job preparations. The reason for this is likely because with the major programs students have more flexibility in choosing their courses for completion of the program. They could potentially skip the courses that are known for having a low GPA, which can be one way to maintain a higher GPA for graduate admission. Also, with a double major, students are still able to choose direct research courses that are needed for graduate studies. Their course selection can be more focused on the areas of interest if they know which graduate studies they want to apply.

Lastly, with double majors, students can also apply for jobs in two types of fields, which increases their options for job selection and opportunities. The Government of Canada's job bank determines the job market for chemists, biochemists, and environmental chemists within the next 3 years to be fair. Ontario's median wages are also calculated by the GOC as \$38.17/hour for all three of these occupations (Government of Canada). However, job search engines like Indeed show varying results for these fields with chemistry revealing the highest search return, shown in Figure 11. As stated in the Common University Data Ontario, the employment rate is generally lower than the other undergraduate programs offered by the University. Compared to other programs, the job demand for biological chemistry and chemistry are much less and the employment rate for undergraduate students are low, this might be

another reason why students either do not choose the specialist program or switch out from the program to other ones that appear to have more job opportunities in the future.

Conclusion

Although many limitations do exist in the data collection and analysis part of this project, there is a potential for further research as this issue is important for the sustainability of the Department of Physical and Environmental Science at UTSC. The academic development and the personal growth of students in these fields will allow them to pursue their passion with well-informed perspectives and worldly context. Education provides students with tools and the opportunity to decide how they would contribute to society. The department is well equipped to address all these issues, as we have an extremely qualified and diverse faculty, it is only a matter of bringing these issues to their attention and their willingness to share data and change course curriculum.

Recommendations

Based on the limited data we have, there are two possible future recommendations that the Department can take to improve the situation. The first one is to increase advertisement for both the biological and chemistry specialist programs. One of the attractive features for both programs is that they are accredited by the Canadian Society of Chemistry (CSC). However, based on the survey result in Figure 12, 88% of the students are unaware of this fact. The accreditation means that students who graduated with the degree meet the minimal work skill requirement in this field. The promotion of this accreditation is likely to increase the students' interest to enrol in the specialist program as it puts them in advantage for future job applications, as opposed to students who graduate with major programs since the major programs are not accredited by CSC.

Another recommendation is to offer combined programs with a Bachelor's degree and Master's degree. As shown in Figure 13, the Department has two developed combined degrees with either Master of Environmental Science or Master of Engineering. However, the program is limited to the environmental specialist students, which is why the environmental chemistry specialist program tends to have more enrollment than the chemistry and biological chemistry programs. Opening the admission with the Master's in Engineering degree to the biological chemistry and chemistry specialist programs or developing a combined program that is suitable for these two specialist programs will likely increase the specialist program enrollment, as it allows students to apply for Master's in their third year and allows them to take courses that can be used as credit for both degrees in their fourth year.

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Appendices

Table 1. Main program options for Physical and Environmental Science students.

Specialist	Environmental science	Chemistry	Physic
	Environmental biology	Chemistry or Biological chemistry	Physics and astrophysics
	Environmental geoscience	Environment chemistry	Environmental physics
Major	Environmental science major	Chemistry or biochemistry Major	Physics and astrophysics major

Table 2) Enrollment Data for Physical Science Programs at UTSC

	Physical Science	Biological Science & Agriculture	Other Art & Science	Totoal
	Total Enromment			
2009-2010	103	1183	2244	3530
2010-2011	125	1187	2422	3734
2011-2012	130	1212	2309	3651
2012-2013	126	1249	2503	3878
2013-2014	153	1359	2939	4451
2014-2015	216	1439	3154	4809
2015-2016	308	1484	3286	5078
2016-2017	400	1467	3106	4973
2017-2018	451	1364	3005	4820

Table #3) Types of Metadata

Type of Metadata	Description	Source of Data (where and when the data will be obtained)
Program Enrollment Number	Obtain historical program enrollment number (10 consecutive years) for all Specialist & Major in Chemistry/Biochemistry and Environmental Science	Data Obtained from Professor Effiette Sauer and Mari Motrich on January 28, 2020
Enrollment of CHMD91/90	Obtain historical program enrollment number (10 consecutive years) for CHMD91/90	Data Obtained from Professor Effiette Sauer and Mari Motrich on January 28, 2020
# of Students Graduated in the programs	Obtain historical program graduation number (10 consecutive years) for all Specialist & Major in Chemistry/Biochemistry and Environmental Science	Request data to Professor Effiette Sauer and Mari Motrich, still waiting for response
Chemistry/Biochemistry Program Student Survey results	Obtain Student survey results which include the relative questions regarding about why students prefer major other than specialist program	Data Obtained from Professor Effiette Sauer on January 24, 2020

List of Program and List of course requirements	Obtain the list of Program offered by the Department of Physical and Environmental Science, and the list of course requirements for graduation	Data will be obtained from UTSC website: https://utsc.calendar.utoronto.ca/list-of-courses/a https://utsc.calendar.utoronto.ca/list-of-programs/a (To be obtained by Feb 12)
Possible Job Opportunities + Average Salary	Research for the job market, such as possible job position, job opportunities and average salary etc for students graduated in both specialist and major programs. Also, for other popular programs such as statistics, engineering, and computer science.	Data will be obtained from multiple sources such as UTSC'S Academic Advising & Career Centre https://www.utsc.utoronto.ca/aacc/what-can-i-do-with-my-degree Google, Indeed, Mendeley etc (To be obtained by Feb 12)
Master/PH.D programs (admission requirements)	Research for the possible graduate programs and future academic path for students graduated in both specialist and major programs	Data will be obtained from U of T website as reference of possible Master/PH.D programs (To be obtained by Feb 12)



Figure 1) Enrollment statistic for specialist programs

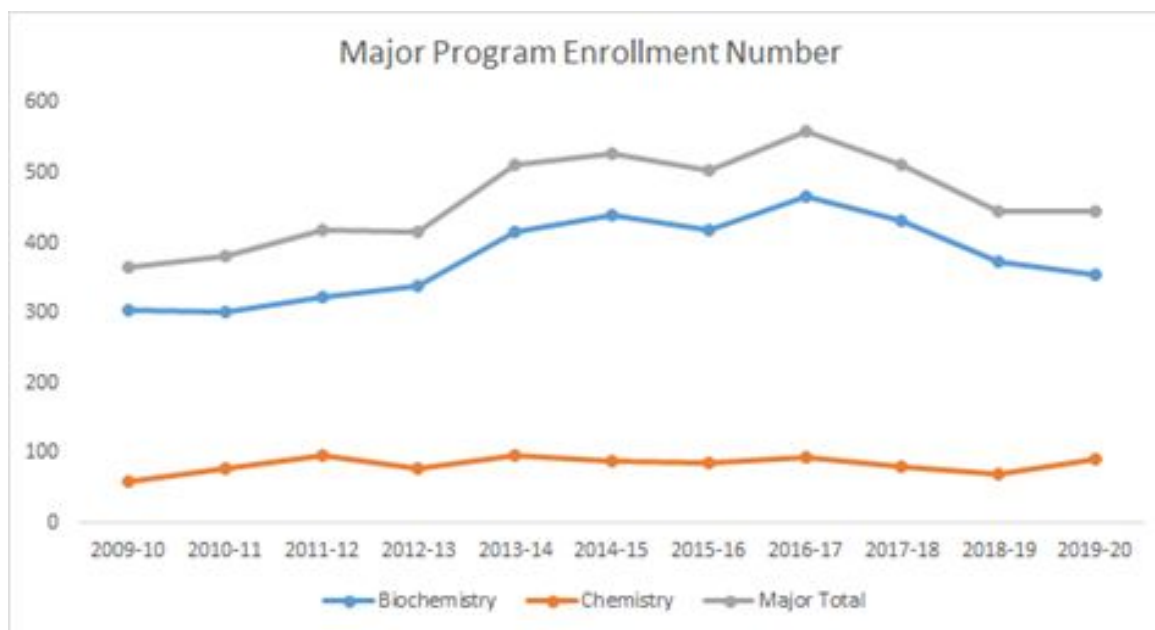


Figure 2) Enrollment statistic for major programs

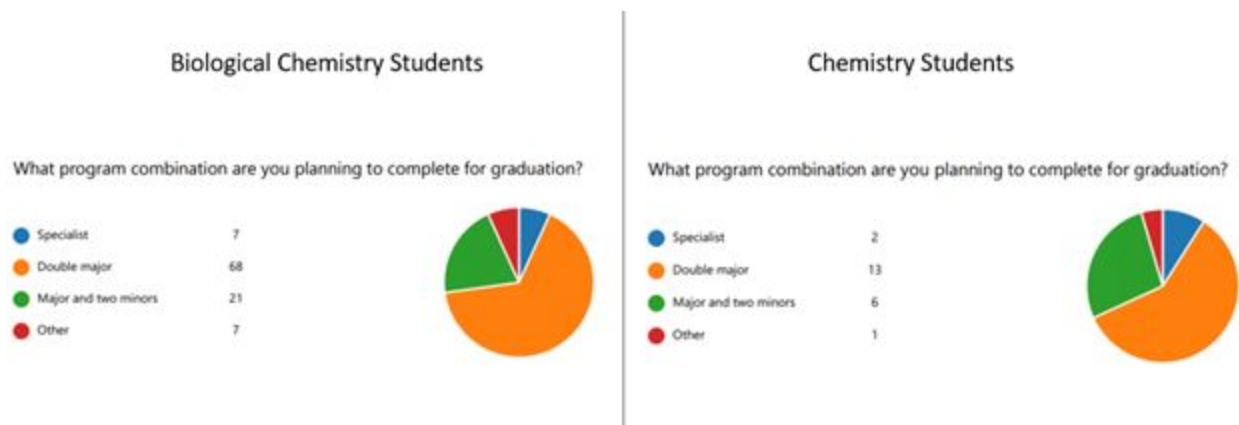


Figure 3) Selected survey question: program combination

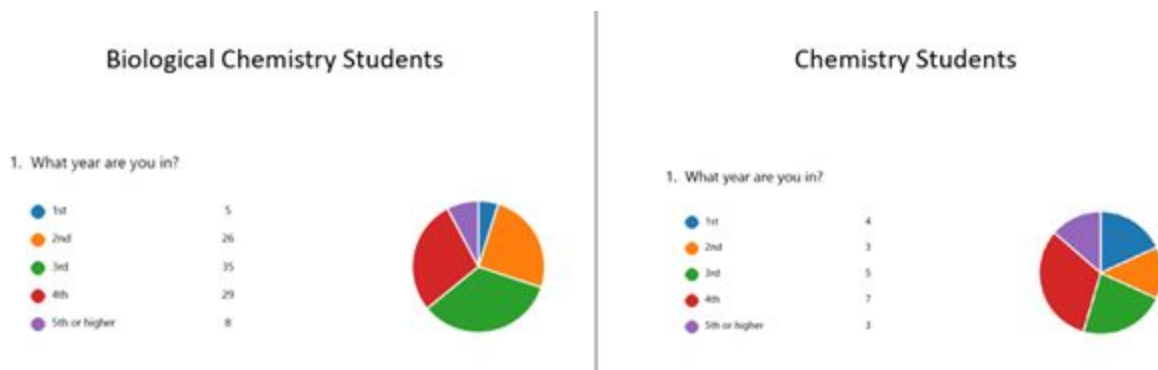


Figure 4) Selected survey question: year of study

Figure 5) Selected survey question

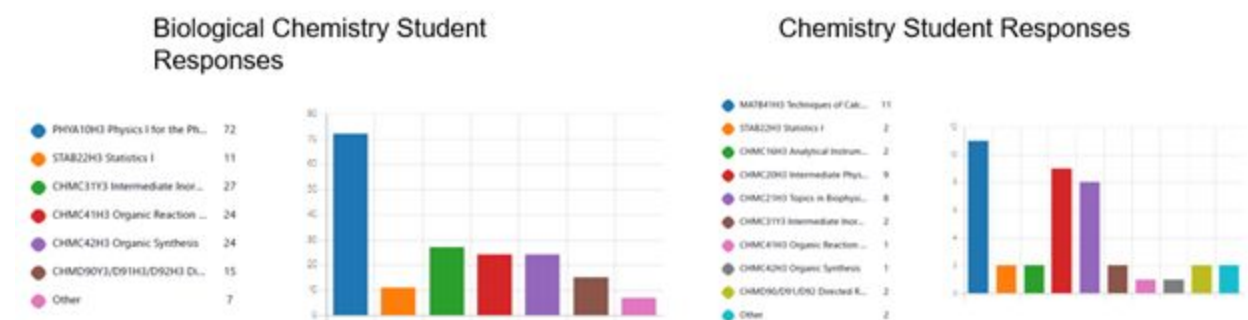


Figure 6: selected survey question: courses student avoid



Figure 7) first-year courses DPES offers in respective to program

First Year:

BIOA01H3 Life On Earth: Unifying Principles
 BIOA02H3 Life on Earth: Form, Function and Interactions
 CHMA10H3 Introductory Chemistry I: Structure and Bonding
 CHMA11H3 Introductory Chemistry II: Reactions and Mechanisms
 MATA30H3 Calculus I for Physical Sciences
 [MATA35H3 Calculus II for Biological Sciences or MATA36H3 Calculus II for Physical Sciences]
 PHYA10H3 Physics I for the Physical Sciences

Second Year:

BIOB10H3 Cell Biology
 BIOB11H3 Molecular Aspect of Cellular and Genetic Processes
 BIOB12H3 Laboratory for Cell and Molecular Biology
 CHMB31H3 Introduction to Inorganic Chemistry
 CHMB41H3 Organic Chemistry I
 CHMB42H3 Organic Chemistry II

Second or Third Year:

CHMB16H3 Techniques in Analytical Chemistry
 CHMB21H3 Chemical Structure and Spectroscopy
 CHMB23H3 Introduction to Chemical Thermodynamics and Kinetics: Theory and Practice
 STAB22H3 Statistics I

Third Year:

BIOC12H3 Biochemistry I: Proteins and Enzymes
 BIOC13H3 Biochemistry II: Bioenergetics and Metabolism
 BIOC23H3 Practical Approaches to Biochemistry
 CHMC47H3 Bio-Organic Chemistry

Third or Fourth Year:

CHMC11H3 Principles of Analytical Instrumentation
 CHMC31Y3 Intermediate Inorganic Chemistry
 [CHMC41H3 Organic Reaction Mechanisms or CHMC42H3 Organic Synthesis]

Figure 8) Biological chemistry specialist requirement course list

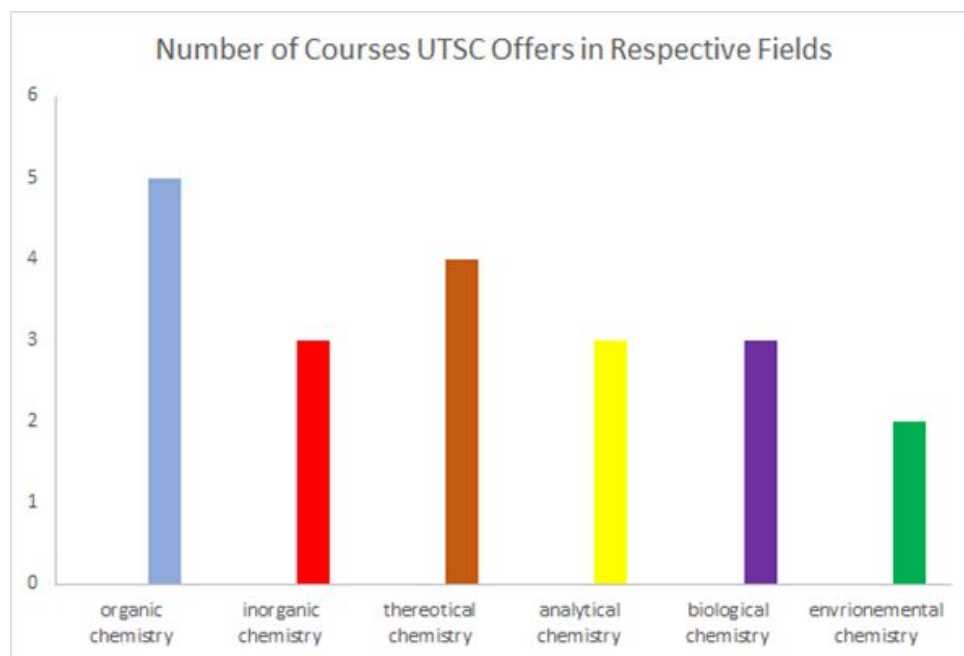


Figure 9. Number of courses in respective chemistry field DPES offers

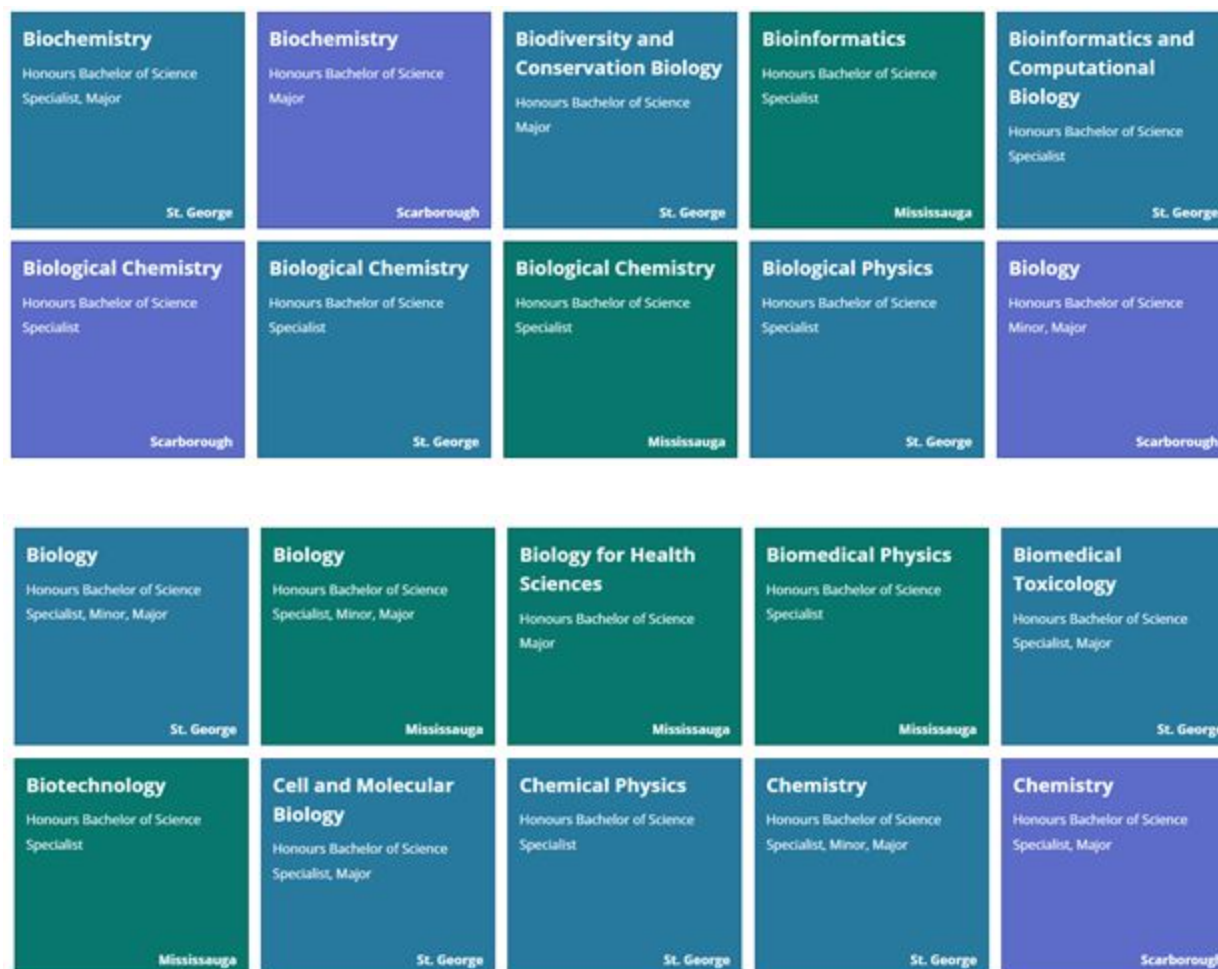
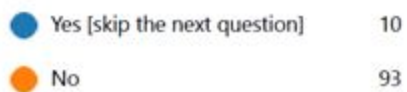


Figure 10) specialist programs offered by all campuses

	Environmental Science	Chemistry	Biochemistry
Job Market in Ontario (Indeed)	266	312	120
Avg. Starting Salary Ontario (Neuvoo)	24,699	26,325	37,545

Figure 11) Job Market in Ontario

10. The biological chemistry specialist was recently accredited by the Canadian Society for Chemistry (CSC); the biochemistry major is not accredited. Were you aware of this distinction?



10. The chemistry specialist was recently accredited by the Canadian Society for Chemistry (CSC); the chemistry major is not accredited. Were you aware of this distinction?

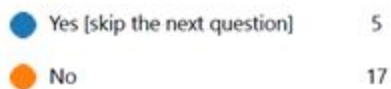


Figure 12) Selected survey question: student knowledge about CSC

The Combined Degree Programs options are:

Department of Biological Sciences

- Conservation and Biodiversity (Specialist), Honours Bachelor of Science/ Master of Environmental Science
- Integrative Biology (Specialist), Honours Bachelor of Science/ Master of Environmental Science

Department of Physical and Environmental Sciences

- Environmental Biology (Specialist), Honours Bachelor of Science/ Master of Environmental Science
- Environmental Biology (Specialist Co-op), Honours Bachelor of Science/ Master of Environmental Science
- Environmental Chemistry (Specialist), Honours Bachelor of Science/ Master of Environmental Science
- Environmental Chemistry (Specialist Co-op), Honours Bachelor of Science/ Master of Environmental Science
- Environmental Geoscience (Specialist), Honours Bachelor of Science/ Master of Environmental Science
- Environmental Geoscience (Specialist Co-op), Honours Bachelor of Science/ Master of Environmental Science
- Environmental Physics (Specialist), Honours Bachelor of Science/ Master of Environmental Science
- Environmental Physics (Specialist Co-op), Honours Bachelor of Science/ Master of Environmental Science

Combined Degree Programs options are:

- Environmental Biology (Specialist), Honours Bachelor of Science/ Chemical Engineering & Applied Chemistry, Master of Engineering
- Environmental Biology (Specialist Co-op), Honours Bachelor of Science/ Chemical Engineering & Applied Chemistry, Master of Engineering
- Environmental Biology (Specialist), Honours Bachelor of Science/ Civil Engineering, Master of Engineering
- Environmental Biology (Specialist Co-op), Honours Bachelor of Science/ Civil Engineering, Master of Engineering
- Environmental Chemistry (Specialist), Honours Bachelor of Science/ Chemical Engineering & Applied Chemistry, Master of Engineering
- Environmental Chemistry (Specialist Co-op), Honours Bachelor of Science/ Chemical Engineering & Applied Chemistry, Master of Engineering
- Environmental Chemistry (Specialist), Honours Bachelor of Science/ Civil Engineering, Master of Engineering
- Environmental Chemistry (Specialist Co-op), Honours Bachelor of Science/ Civil Engineering, Master of Engineering
- Environmental Geoscience (Specialist), Honours Bachelor of Science/ Chemical Engineering & Applied Chemistry, Master of Engineering
- Environmental Geoscience (Specialist Co-op), Honours Bachelor of Science/ Chemical Engineering & Applied Chemistry, Master of Engineering
- Environmental Geoscience (Specialist), Honours Bachelor of Science/ Civil Engineering, Master of Engineering
- Environmental Geoscience (Specialist Co-op), Honours Bachelor of Science/ Civil Engineering, Master of Engineering
- Environmental Physics (Specialist), Honours Bachelor of Science/ Chemical Engineering & Applied Chemistry, Master of Engineering
- Environmental Physics (Specialist Co-op), Honours Bachelor of Science/ Chemical Engineering & Applied Chemistry, Master of Engineering
- Environmental Physics (Specialist), Honours Bachelor of Science/ Civil Engineering, Master of Engineering
- Environmental Physics (Specialist Co-op), Honours Bachelor of Science/ Civil Engineering, Master of Engineering

Figure 13) Program combinations offered by DPES regarding the environmental branch