FINAL ASSESSMENT REPORT

REPORT OF ACADEMIC STANDARDS COMMITTEE TO SENATE

June 2, 2015

PERIODIC PROGRAM REVIEW

CHEMISTRY (BSc)
Faculty of Science

1. BASIC INFORMATION
a) Program Description
The Bachelor of Science in Chemistry, which started in 2005, is a full time, four year degree program. Students are able to complete the regular program or opt to take the Chemistry – Applied Physics option. The regular program and the options can all be taken with or without a co-op option (which adds another year to the program). Students also have access to an Optional Specialization in Management Sciences.

b) Program History
- When the Ryerson Institute of Technology was established in 1948, one of the three-year diploma programs was Chemical Technology.
- By the mid 1960's, this program had options in Industrial Chemistry, Applied Chemistry and Polymer Chemistry. Laboratory Science was added in 1967. The program combined some elements of the Applied Chemistry option with newly designed courses in biology, microbiology, and biochemistry.
- In 1971 a fourth year was added to both the Chemical Technology and Laboratory Science programs and the first Bachelor of Technology (Laboratory Science) degree was awarded in 1973.
- During the 1970's and 1980's, Chemical Technology gradually changed to Chemical Engineering Technology, and the name was changed to Chemical Engineering in 1984. The program was accredited by the Canadian Society for Chemistry (CSC) in 1985 (and reaccredited in 1992 and 2003).
- In 1989, the Laboratory Science program was renamed Applied Chemistry and Biology.
- Growth in faculty research activities prompted the development of new science programs in Biology, Chemistry, Contemporary Science, Mathematics and its Applications, and Medical Physics, all with a common first year platform. The Chemistry and Biology programs were launched in 2005, at which time the Applied Chemistry and Biology program was phased out.
- In order to meet CSC guidelines, some changes were made to the Chemistry program in 2007; the Chemistry and Chemistry Co-Operative Education programs were accredited in 2009.
- The Chemistry Applied Physics option did not meet CSC accreditation requirements, in part due to the lack of a biochemistry component. Due to lack of student interest in Computational Chemistry, this option and its Co-Operative Education version were eliminated effective September 2010.
- A Master of Science in Molecular Science was launched in 2006, followed by a PhD in Molecular Science in 2010.

2. DEVELOPMENTS SINCE PREVIOUS PROGRAM REVIEW

a) Previous Developmental Plan
This is the first periodic program review for the Bachelor of Science in Chemistry. The program was implemented with the first cohort of students entering their first year of study at Ryerson in the Fall of 2005.

b) Annual Academic Plan
One of the goals (Objective 2) of the academic plan is to improve undergraduate programs in pedagogy, delivery and technology; to review and remove options not well used by students; and to renew undergraduate laboratory infrastructure. The Chemistry program underwent accreditation review by the Canadian Society for Chemistry in 2009 and was fully accredited. The Computational Chemistry stream of the Chemistry program was not popular; no students had ever enrolled in this option, therefore the option was eliminated.

Two undergraduate chemistry teaching laboratories had been identified as in urgent need for renovation: KHN 205 and KHN 207. Funding was approved for the KHN 205 renovation, but almost the entire budget was consumed by major expansion of the HVAC, installation of air make-up capacity, and the fume hoods themselves. Construction was completed in Fall 2011. With a new science building as a rising priority in University capital projects, approval of further major laboratory renovations in Kerr Hall is unlikely. Chemistry teaching labs continue to suffer from infrastructure deficiencies.

An additional goal of Objective 2 is to increase the student satisfaction with their experience in the Chemistry program at Ryerson. The goal for graduate satisfaction is 85%; in 2008 the combined score for both chemistry and biology was 74%; by 2011, the combined score for overall satisfaction for both chemistry and biology was 81% (67.5% satisfied and 18.8% very satisfied). It should be noted that the sample size is very small; 15 biology students and 3 chemistry students responded.

The NatSome results from the National Survey of Student Engagement (NSSE) 2011 follow:

Table 1 NSSE 2011 *Entire educational experience* (% good + excellent)

Program Year	**Chemistry**	FEAS	Ryerson
1st year	**74 (n=15)**	72 (n=373)	81 (n=1612)
4th Year	**82 (n=17)**	77 (n=384)	77 (n=2170)

Table 2 NSSE 2011 *Would you choose to attend the same school if you were to start all over again* (% probably yes + definitely yes)

Program Year	**Chemistry**	FEAS	Ryerson
1st year	**69 (n=16)**	78 (n=373)	86 (n=1612)
4th Year	**94 (n=17)**	76 (n=384)	78 (n=2170)

Table 3 NSSE 2011 *Worked harder than they thought they could to meet instructors standards or expectations* (% often and very often)

Program Year	**Chemistry**	FEAS	Ryerson
1st year	**40 (n=15)**	50 (n=407)	54 (n=1739)
4th Year	**67 (n=18)**	60 (n=400)	60 (n=2261)

Table 4 NSSE 2011 *Put together ideas or concepts from different courses to complete assignments or during class discussion* (% often and very often)

Program Year	**Chemistry**	FEAS	Ryerson
1st year	**38 (n=16)**	48 (n=410)	61 (n=1755)
4th Year	**50 (n=18)**	70 (n=404)	74 (n=2286)

Table 5 NSSE 2011 ***How often do you worked on papers or projects requiring that you integrate ideas or information from a variety of sources*** **(% often and very often)**			
Program Year	**Chemistry**	FEAS	Ryerson
1st year	**71 (n=17)**	60 (n=433)	79 (n=1837)
4th Year	**74 (n=17)**	84 (n=413)	91 (n=2341)

c) Response to Issues Arising from Previous Accreditation Assessment

The Chemistry program was reviewed by the Canadian Society for Chemistry in 2009 for accreditation. At the time of the site accreditation review, the Department of Chemistry and Biology was part of the Faculty of Engineering, Architecture and Science. As of July 2012, the Department is now one of the founding departments of the Faculty of Science.

For the purposes of the accreditation review, the PCS 400 Quantum Physics course was considered equivalent to a Quantum Chemistry course. While students gave the site visit team compliments about PCS 400, chemistry faculty and students have expressed reservations about the course since then. The course has become a required component of the Medical Physics undergraduate program, with PCS prerequisites not normally obtained by Chemistry students. With this change, Chemistry students are no longer adequately prepared to succeed in the course as taught.

The Chemistry – Applied Physics program (including co-op) was also reviewed in 2009 and was deemed not accreditable due to the lack of a biochemistry course and insufficient hours of instruction in both chemistry laboratories and chemistry courses as a whole.

Other comments about the main Chemistry program:

- The reviewers noted that “the age of the building, its physical state, and the overall space associated with the Department of Chemistry and Biology has implications for the quality of the Chemistry education taking place, and for the growth of the department’s research profile.”
- The Chemistry program exceeds the required number of mathematics and computer science courses with two required calculus-based mathematics and one computer science course required in the first year, a calculus course in the second year, and a course in statistics in the third year.
- The reviewers thought that the CHY 261 Biochemistry course should be re-labelled as a BCH course. This change was put into effect with the 2011-2012 course calendar and included renaming CHY 361 Intermediary Metabolism I and CHY 362 Intermediary Metabolism II as BCH 361 Advanced Biochemistry I and BCH 362 Advanced Biochemistry II, respectively. The content and descriptions of these courses have not changed.
- Students were generally very positive about the chemistry course offerings and the quality of instruction. They particularly liked their smaller class sizes and interactions with faculty and staff.
- Students attempting to complete the minor in biology reported that despite the large selection of courses, scheduling limits their actual selection of courses and in many cases makes obtaining the minor within a four year program of study impossible. Since the 2009 accreditation site visit, scheduling concerns have only increased. Recently, Scheduling has been working collaboratively with the Department to try to minimize conflicts between elective courses, with some success.
- The site visit team recommended that we hire an additional chemist in the area of organic/environmental chemistry. A synthetic organic chemist interested in the design of new materials for sustainable energy production was hired in 2011.
- The site visit team was impressed with the Ryerson library holdings, in particular the paper and electronic journals. At the time of the accreditation review, we had just one seat available on SciFinder Scholar. This is the standard tool for searching the chemical literature and therefore is used extensively by faculty and students for both teaching and research activities. The number of seats has since been increased to an unlimited number.

- The accreditation report recommends that the number of Chemical Technologists be increased to 3; this was done in Fall 2011.
- The site visit team strongly recommended that Ryerson renovate KHN 205 and KHN 207 to modern standards.

A new Science Building remains at the top of the wish list for the Chemistry program, the Department of Chemistry and Biology, and the Faculty of Science. The need for such a facility is even more pressing with the establishment of the new Faculty of Science, and growth in undergraduate programs, undergraduate admissions in all science programs, growth in graduate programs, and increases in the number of faculty who need not only office space, but adequate research space and infrastructure.

3. SOCIETAL NEED

a) Current and Anticipated Societal Need

Chemists find employment in a wide variety of industrial sectors, including chemical, petrochemical, agrochemical, pharmaceutical and other scientific companies, mineral, metal, pulp and paper, food, and other manufacturing industries, education, health/medical, and government, as well as in analytical laboratories. In Ontario, most chemists are employed in the GTA, Ottawa, Hamilton-Niagara Peninsula and Kitchener-Waterloo-Barrie. Therefore, the chemistry program at Ryerson is ideally situated to provide chemistry graduates for employment locally. Chemists generally have fairly high employment rates.

Overall, our alumni are quite successful at pursuing opportunities and finding employment in areas directly related to their degree. In our sample set, 60% have pursued graduate training and approximately 80% are directly using their chemistry/science knowledge in some way.

b) Existing and Anticipated Student Demand

The Chemistry program has met its target admissions each year with approximately 11 to 12 applicants per position (average from 2005 to 2009). The interest in these science programs compares very favourably with programs in the Faculty of Engineering, Architecture and Science (average 8 applicants per registrant, average from 2005 to 2009) and Ryerson as a whole (10 applicants per registrant, average from 2005 to 2009).

The Chemistry program has seen a steady increase in first year enrolment from 43 (Fall 2005) to 56 (Fall 2010), further supporting a growing interest in the chemistry program (Table 6). The admission target is currently 56-60 students. The overall headcount in the Chemistry program is approximately 160 to 170 students.

Table 6 ENROLMENT	**F2005**	**F2006**	**F2007**	**F2008**	**F2009**	**F2010**	**F2011**
Engineering, Architecture & Science	1271	1296	1373	1508	1497	1592	1731
Science	371	390	452	488	447	534	626
Chemistry	**43**	**52**	**54**	**50**	**49**	**56**	**63**

The ratio of male to female students in chemistry programs has traditionally been higher than in some other disciplines. Our chemistry program is no exception; in most years since 2005, the percentage of male students (53% weighted average from 2005 to 2011) in the program has been higher than in the Biology (43%) and Contemporary Science (44%) programs and higher than at Ryerson as a whole (45%).

Full-time enrolment dropped down from an average of about 80% from 2005 through 2009 to 70% in 2010 and 53% in 2011. Some students have restricted course loads because of their academic standing, some cannot access the courses they want to take because of scheduling issues, some students are part-time because they have only a few courses remaining to complete their degrees, while others choose to work part-time for financial reasons.

4. PROGRAM OUTCOMES

a) Program Outcomes

The chemistry faculty in the Department of Chemistry and Biology value a Chemistry program which is accredited and produces graduates capable of entering the work force as professional chemists or pursuing further study as graduate students. The learning outcomes developed for this program support these values and are modelled on the scientific process.

	Graduates of the Chemistry program should be able to:
Knowledge	1. Demonstrate the integrated nature of the essential facts, concepts, principles and theories in each of the five core areas of chemistry: a) Analytical Chemistry b) Biochemistry c) Inorganic Chemistry d) Organic Chemistry e) Physical and Theoretical Chemistry
Scientific Inquiry	2. Identify problems, formulate questions, select and interpret relevant and appropriate resources and data.
Experimental Design	3. Devise methods to test original hypotheses with attention to detail.
Experimentation & Safety	4. Conduct standard laboratory procedures using appropriate synthetic methods and instrumentation; 5. Demonstrate understanding of safe chemical handling and disposal; assess and manage risks of chemicals and procedures.
Analysis & Problem Solving	6. Manipulate and critically evaluate data and experimental evidence in order to arrive at appropriate and defendable conclusions.
Communication and Collaboration	7. Decipher and communicate technical information clearly and concisely orally, in writing, and in visual form, for a range of audiences; 8. Collaborate effectively and reliably with faculty and peers (listen, provide constructive feedback, contribute equitably and in a timely manner).
Autonomy and Awareness	9. Understand the limits of their own knowledge and recognize uncertainty and ambiguity; confidently exercise responsibility in decision making and the consequences of their decisions; 10. Demonstrate curiosity and actively pursue a higher level of understanding. Interpret the societal impact of chemistry in everyday life, technology, and the environment.
Professional Conduct	11. Demonstrate ethical behaviour, accountability as well as personal and academic integrity; 12. Demonstrate time and resource management.

Students reach a level of proficiency towards *learning outcome 1a* analytical chemistry by the end of their third year, which is reinforced with the environmental science course. With only one required biochemistry course in the program, it is not possible for students to reach a level of proficiency in this sub-discipline (*learning outcome 1b*) without a major restructuring of the program. Proficiency in biochemistry is neither expected nor required for accreditation of the program. We are not satisfied with the level of proficiency reached by our graduates in *1c*) inorganic chemistry or *1d*) organic chemistry, areas that are our strengths in terms of number of faculty focus. Students are not able to reach proficiency in these areas because there are not enough courses in these areas. We plan to address these deficiencies through the development of several new chemistry elective courses. Proficiency in *learning outcome 1e*) physical and theoretical chemistry is also difficult for students to achieve. We offer only two physical chemistry courses and have only two faculty capable of teaching these courses, both of whom have administrative roles and reduced teaching loads.

Students are able to reach a suitable level of proficiency in *learning outcome 2* (scientific inquiry) through the chemistry elective courses. Student achievement towards proficiency in program *learning outcome* 3 (experimental design) and 4A (experimentation) are hampered by the use of cook-book style labs and not enough labs in sub-disciplines other than analytical chemistry. We plan to address this shortcoming in the program by developing an integrated synthesis laboratory course. L*earning outcome 4B* (safety) would also be strengthened with this course.

Proficiency in *learning outcome* 5 (analysis and problem solving) is attained through the chemistry elective courses. A level of proficiency in *learning outcomes* 6A (communication) and 6B (collaboration) should be achieved fairly early in the program, but is only reached in the chemistry electives. Student achievement of these *learning outcomes* should be examined and built into existing courses wherever possible.

Learning outcomes 7A (uncertainty & limits of knowledge, decision-making) and 7B (curiosity, higher understanding & societal impact) are reached in the chemistry elective courses, but have little reinforcement or introduction. In particular, issues relating to societal impact of chemistry could be introduced in courses as part of the examples that are used and could be assessed on tests and assignments.
Learning outcomes 8A (integrity & accountability) and 8B (time and resource management) reach a level of proficiency by the end of third year through the core required courses.

b) Program Consistency with other Academic Plans
Because the learning outcomes are intended to support a high-quality accredited program and to produce graduates with the appropriate knowledge and skills to solve problems, design and perform experiments safely and effectively, communicate clearly, work well with others, use resources effectively and demonstrate sound ethical conduct, the program learning outcomes are in alignment with the ultimate goal of the University: to offer high quality societally relevant programs. The Chemistry Program and the learning outcomes of the Chemistry Program are consistent with the University's Mission Statement in that the students in the Chemistry Program learn knowledge and theory and apply these to chemical problems.

The Chemistry program, and in particular the learning outcomes of the program, are in alignment with the Academic Plan's priorities:

- The main purpose of the program learning outcomes is to train students to become independent thinkers capable of meeting the need for chemists in a variety of sectors. Conformation to the requirements for CIC accreditation as well as the program learning outcomes combine to create a high quality program and ensures that the program meets the expectations of the Chemical profession in terms of content and quality.
- The program supports students to develop the study, learning, laboratory, communication and collaboration skills that will make them successful in the program and beyond.
- The existing Chemistry Program offers students some choice in programming; however, student choice is frequently limited by the availability of elective courses and by scheduling issues.
- Students engage in the SRC activity when they opt to take the Chemistry Thesis project in their fourth year of study. Additional opportunities to participate in SRC activities exist through summer

employment in research labs on and off campus, opting for the Cooperative education option in the Chemistry program, or through volunteer work.

- The experimentation that forms the basis of teaching laboratory curricula is intrinsically experiential. Chemistry students have many experiential learning opportunities in the laboratories that form a core part of the curriculum, the writing assignments associated with these labs and other course components, as well as through Co-Operative education and these research projects.
- The newly established Faculty of Science enhances the University's reputation and makes the existing science programs at Ryerson much more visible. Full accreditation of the Chemistry and Chemistry Co-Op programs further enhances the reputation of Ryerson. Formally, only learning outcomes1 (Knowledge) and 4/5 (Experimentation) are considered as part of the accreditation process. However, the combination of all the learning outcomes makes the program very solid.

5. ACADEMIC QUALITY

a) Description of the Program Curriculum and Structure

The first year of the program is shared with other science programs, namely, Biology, Contemporary Science, and Medical Physics. The courses in this first year include Biology, Chemistry, Mathematics, and Physics, Computer Science and Liberal Studies.

The concepts and skills introduced in the first year courses are further developed in the core chemistry courses of second year (analytical chemistry, biochemistry, organic chemistry, physical chemistry) and third year (inorganic chemistry). In addition, students take two additional mathematics courses: calculus in their second year, and statistics in their third year of the program.

The main subdivisions of chemistry are further developed by the core courses of third year. In particular, students strengthen their knowledge of analytical methods with additional courses in Analytical Chemistry (CHY 330 and CHY 331); additional courses (CHY 339 and PCS 400) strengthen and extend their core knowledge in chemistry and the communication course (CMN 600) is meant to provide students with solid writing skills so that they can communicate professionally with other scientists via posters, oral presentations and written documents such as reviews and research articles.

In the fourth year of the program, students are required to take an Environmental Science course (CHY 423). Students choose eight professionally related courses in which they can further specialize in chemistry, or can broaden their scientific knowledge base with courses in the other sciences (biology and physics) and mathematics. Two of these electives must be chemistry courses to ensure that students have met the laboratory hour requirements of accreditation. The chemistry courses in their selection mostly bring students to a level of proficiency in chemistry concepts and skills at the undergraduate level, while introducing students to more specialized niche areas in chemical disciplines. Students may also choose to take either the Chemistry Thesis Project or an Independent Study course in which they perform laboratory and/or literature research and present the findings of their research in professionally appropriate formats, including an oral presentation and a written thesis.

Aside from the chemistry courses required in the Chemistry program and allied sciences, the Department also offers core chemistry courses to students in Engineering programs, especially Chemical Engineering, as well as to students in Nutrition, and Public and Occupational Health. Students in the Arts have access to first year General Chemistry courses. The Department also offers some Liberal Studies chemistry courses to students outside of the Faculties of Science and Engineering and Architectural Science.

On average, 31% of the students in the Chemistry regular and Co-Operative education programs complete minors as part of their undergraduate degree program – typically in Biology and Mathematics. The graduates from the Chemistry – Applied Physics program have not obtained minors.

CURRICULUM - CHEMISTRY	
1st SEMESTER REQUIRED: BLG 143 Biology I CHY 103 General Chemistry I CPS 118 Introductory Programming for Scientists MTH 131 Modern Mathematics I PCS 120 Physics I SCI 180 *Orientation * pass/fail	**2nd SEMESTER** REQUIRED: BLG 144 Biology II CHY 113 General Chemistry II MTH 231 Modern Mathematics II PCS 130 Physics II LIBERAL STUDIES: One course from Table A
3rd SEMESTER REQUIRED: CHY 142 Organic Chemistry I CHY 213 Analytical Chemistry I CHY 381 Physical Chemistry I MTH 330 Calculus and Geometry LIBERAL STUDIES: One course from Table A	**4th SEMESTER** REQUIRED: BCH 261 Biochemistry CHY 223 Analytical Chemistry II CHY 242 Organic Chemistry II CHY 382 Physical Chemistry II LIBERAL STUDIES: One course from Table A
5th SEMESTER REQUIRED: CHY 330 Atomic and Molecular Spectroscopy CHY 331 Basic Chromatography CHY 344 Inorganic Chemistry MTH 380 Probability and Statistics I LIBERAL STUDIES: One course from Table B	**6th SEMESTER** REQUIRED: CHY 339 Characterization of Organic Compounds CHY 449 Inorganic Chemistry II CMN 600 Science, Communication and Society PCS 400 Quantum Physics I PROFESSIONAL AND PROFESSIONALLY-RELATED: One course from Table I
7th SEMESTER LIBERAL STUDIES: One course from Table B. PROFESSIONAL AND PROFESSIONALLY-RELATED: Four courses from Table I	**8th SEMESTER** REQUIRED: CHY 423 Environmental Science LIBERAL STUDIES: One course from Table B. PROFESSIONAL AND PROFESSIONALLY-RELATED: Three courses from Table I

Notes:

i. First two semesters are common to Biology, Chemistry, Contemporary Science, Mathematics and its Applications, and Medical Physics - Both Co-operative and Regular Programs

ii. Students in the Applied Physics Option follow a separate curriculum from 3rd to 8th semester

iii. Students in Co-operative Program follow a separate curriculum from 5th to 8th semester

PROFESSIONAL AND PROFESSIONALLY-RELATED - TABLE I Regular and Co-operative Programs (excluding Applied Physics Option)	
A minimum of **two** from the following:	
BCH 361 Advanced Biochemistry I CHY 40A/B† Research Project-Thesis CHY 431 Applied Analytical Chemistry	CHY 434 Analytical Chemistry of Complex Samples CHY 600 Organic Reaction Mechanisms † A multi-term course (equivalent to two single-term courses)
A maximum of **six** from the following:	
BCH 362 Advanced Biochemistry II BLG 151 Microbiology I BLG 251 Microbiology II BLG 307 Molecular Biology BLG 311 Cell Biology BLG 351 Applied Microbiology BLG 400 Genetics BLG 401 Ecotoxicology BLG 402 Limnology BLG 567 Ecology BLG 578 Pharmacology BLG 600 Physiology BLG 678 Current Topics in Biology BLG 700 Anatomy BLG 785 Developmental Biology BLG 788 Current Topics in Biotechnology	MTH 210 Discrete Mathematics II MTH 330 Calculus and Geometry MTH 430 Dynamical Systems and Differential Equations MTH 480 Probability and Statistics II MTH 500 Introduction to Stochastic Processes MTH 501 Numerical Analysis I MTH 503 Operations Research I MTH 540 Geometry MTH 601 Numerical Analysis II MTH 603 Operations Research II MTH 607 Graph Theory MTH 609 Number Theory MTH 640 Complex Analysis MTH 710 Fourier Analysis MTH 712 Differential Equations II MTH 714 Logic and Computability

BLG 800 Genomics and Proteomics BLG 856 Immunology BLG 888 Molecular Biology Laboratory CHY 435 Advanced Chemical Instrumentation CHY 436 Pharmaceutical Chemistry CHY 437 Organic Chemistry CHY 445 Materials Chemistry CHY 482 Selected Topics in Chemistry CHY 500 Directed Studies CHY 501 Polymer Chemistry CHY 502 Organometallic Chemistry CHY 706 Computational Chemistry CPS 314 Graphical Modeling MTH 110 Discrete Mathematics I MTH 210 Discrete Mathematics II	MTH 718 Design and Codes MTH 814 Computational Complexity MTH 817 Combinatorics MTH 820 Image Analysis PCS 227 Biophysics PCS 228 Electricity and Magnetism PCS 229 Introduction to Medical Physics PCS 230 Photonics and Optical Devices PCS 300 Modern Physics PCS 335 Thermodynamics and Statistical Physics PCS 352 Nuclear Physics/Radiation Protection PCS 354 Radiation Biology PCS 700 Quantum Physics II

b) Diversity and Inclusion
Throughout the program, students are exposed to many different laboratory skills through the courses that have laboratory components. Along with these hands-on skills, students also learn to communicate their findings in professionally appropriate ways through written laboratory reports. They also learn appropriate conduct in a laboratory environment, and how to work with their colleagues and instructors.

c) Curriculum and Structure
Each of the UDLEs is addressed by one or more of the program learning outcomes. In turn, each of the program learning outcomes is addressed by a number of required courses at different levels of the program, beginning in the first year and continuing through the third and fourth year courses. Professionally related chemistry electives further reinforce the program learning outcomes and therefore the UDLEs.

We noted during our curriculum mapping to our program learning outcomes, that there was some uncertainty amongst faculty regarding the meaning of the levels I, R and P; a number of faculty reserved P (proficiency) for the level of a working chemical professional. This is not the level at which undergraduates would perform upon graduation. The teaching and assessment methods all appeared to support the acquisition of knowledge related to, and specific to, chemistry.

Depth, breadth, and application of knowledge are addressed by four of the UDLEs (1, 2, 3, and 5). The general trend in the required courses in the program is that the first year courses introduce the required knowledge in chemistry and related fields. Some further introduction occurs in second year with courses in major areas of chemistry not addressed in first year, namely organic and biochemistry. Reinforcement of concepts occurs in both second year and third year required courses. Proficiency is reached in the third year analytical courses, but is not reached in any of the other major areas of chemistry unless the appropriate chemistry elective courses are taken.

Ideally, a graduate would have reached proficiency in at least two of the major areas of chemistry through their selection of chemistry electives, which could include a laboratory research thesis (CHY 40A/B). We see the potential lack of proficiency in our graduates related to these UDLEs as a weakness of the current program and plan to address this through the development of new courses to fill in gaps in fundamental knowledge early in the so that this knowledge and the associated skills can be better developed in later courses. At the same time, we are considering repositioning some of the topics between courses to promote better retention of knowledge and to assist the development of knowledge and skills.

UDLE 4 deals with communication skills. These are introduced in first year courses and to some extent in the first half of the second year. Communication skills are reinforced throughout the second half of the second year and the third year courses. Proficiency is reached in fourth year chemistry elective courses. This means that the bulk of the required courses in the program only bring students to a reinforced level of communication skill. Some communication skills could be expected at a higher level beginning in the second year and brought to proficiency in third and fourth year. The biggest hurdle towards developing good communication skills in lower level courses is the large class sizes. In these courses, it is overly difficulty to develop oral communication skills, but written communication skills in the form of laboratory and other written work can be developed.

UDLE 6 deals with autonomy and professional capacity. This is generally well covered, with most courses addressing these expectations. There is a steady progression from introductory through reinforced to proficient using the chemistry elective courses that students take in their fourth year in the program. We could put more emphasis on these skills earlier in the program.

d) Curriculum Development

Curricular changes and development in the chemistry program occur on a number of levels: within a course, between courses in the same discipline, and in the program as a whole. Curricular changes within a course are often small changes made in response to new discoveries and developments in the field.

e) Enrolment in Program Courses

The science programs at Ryerson have had a steady growth in admissions since 1995. The first year courses have been the ones most impacted by this growth because the Biology program has grown faster than the other programs. Other courses taken by Biology program students after first year have also experienced substantial growth, in particular CHY 142 Organic Chemistry I and BCH 261 Biochemistry.

Beginning in the second year courses, class sizes drop quite significantly (aside from CHY 142 Organic Chemistry I and BCH 261 Biochemistry) and represent the number of students in the Chemistry program as well as some students from other programs such as Biology who are taking Chemistry courses in order to obtain a Chemistry minor, to fulfill prerequisites for professional programs, or for interest.

The Chemistry program has seen an increase in the number of small (<30) size chemistry courses as more upper year professionally related chemistry electives have been offered. These courses are typically small because of some self-selection by students into the courses, and because there is a relatively small number of students in the upper years of the chemistry program. The class capacities are generally higher than the course enrolments, suggesting that there is room for expansion in the chemistry program.

f) Relationship to Current Discipline and Profession

CHY 482 Special Topics in Chemistry and CHY 40A/B Research Thesis provide students with the most exposure to new developments in chemistry; in the case of the research project, this is because the students are involved in the discovery process. Small changes to course content are made to incorporate newer reactions and techniques.

Our Chemistry program is not significantly different from comparator Chemistry programs at Brock University, Lakehead University and Windsor University in terms of course content in required courses. However, the chemistry program at Ryerson has at least three fewer total chemistry courses. This has a significant impact on the amount of exposure students have to chemistry and to the opportunities available for students to learn to be chemists. The total number of chemistry courses can only be increased at the expense of core courses in supporting disciplines such as those in mathematics and computer science; the chemistry program includes three more foundational science and related courses than the comparator programs. Another limiting factor is the number of humanities and social science courses required in the Chemistry program, which has three more of this category of course than any of the comparator programs.

g) Professional Practice

Program *learning outcomes 8A and 8B* relate to professional and ethical practice in the field of chemistry. Most of the professional practice is dealt with through lab instruction and grading of Good Lab Practice. Additional discussion regarding professional practice and ethics takes place in lectures and on a case-by-case basis with individual students who need further instruction on ethics. Students who have participated in the thesis course will have had exceptional training in professional practice and ethics.

h) Accreditation

The Chemistry Program at Ryerson is accredited by the Chemical Institute of Canada and is similar to other chemistry programs in Canada. The Chemistry and Chemistry Co-Operative Education program are accredited through 2014.

i) Student Engagement

a) Teaching Methods & Innovative or Creative Content or Delivery

The Chemistry Program is delivered in a traditional manner of lectures and laboratory sessions. However, within the lecture, a variety of different activities occur that allow for student engagement including demonstrations, problem assignments, interactive activities, discussions, in-class activities and exercises, problem-based learning and case studies. Laboratories are an effective means of providing students with experiential learning opportunities and skills that will be useful after graduation. Laboratories are an essential component of the program for accreditation by the Canadian Society for of Chemistry (CSC). In-class delivery of course material allows students in relatively small classes to be engaged in interactive real-time discussions and to demonstrate good oral communication skills.

While all of these activities are related to learning outcome 1 (knowledge of Chemistry), they also support achievement of other learning outcomes in the program, depending on the course and how the activity is used. Each of the learning outcomes is supported by the activities in at least one of the required program courses. Each of the UDLEs is also supported by the teaching methods used in the program (Table 7).

Table 7 Support of Program Learning Outcome and UDLEs by TEACHING METHODS

Teaching Method	Program Learning Outcomes	UDLEs
Lecture	1, 2, 3, 4A, 4B, 5, 6A, 6B, 7A, 7B, 8A, 8B	1-6 (all)
Lab work	1, 2, 4A, 4B, 5, 6A, 6B, 7A, 8A, 8B	1-6 (all)
Demonstrations	1, 2, 5	1, 2a, 3, 6a
Discussion	1, 2, 3, 4, 5, 6A, 6B, 7A, 7B, 8A, 8B	1-6 (all)
Problem Assignments	1, 2, 4B, 5, 6A, 6B, 7A, 7B, 8A, 8B	1-6 (all)
Interactive Activities	1, 5, 6A, 6B, 8A, 8B	1, 2, 3a, 3b, 4, 6
In-class activities	1, 2, 3, 4B, 5, 6A, 6B, 7A, 7B, 8A, 8B	1-6 (all)
Group Work	1, 5, 6A, 6B, 7A, 7B, 8A, 8B	1, 2, 3a, 3b, 4, 5, 6
Case Studies	1, 2, 4A, 4B, 5, 6A, 6B, 8A, 8B	1, 2, 3, 4, 6

j) Experiential Learning Outcomes

The nature of the chemistry profession requires that courses contain experiential learning opportunities throughout the program. Beginning in the first year of studies, students are exposed to hands-on laboratory experiments in chemistry, biology and physics. By the end of the second year of study, chemistry program students have completed at least one course with laboratory component in 4 out of 5 of the major chemistry sub-disciplines. Laboratory skills are further reinforced in core courses with laboratory components throughout the third year of study. By the end of their sixth term, students are asked to use skills learned in previous courses to help them develop their own experiment procedures in both core and elective courses with laboratory components.

Experiential learning laboratory components in required courses of the program allow students to reach proficiency in only a single sub-discipline (Analytical Chemistry). Students that are enrolled in the Thesis Project course (CHY40, taken in the final year of study) will reach proficiency in one (or more) of the 5 sub-disciplines by having completed a research project that requires the student to design and carry out their own experiments in a research laboratory environment under the supervision of a faculty member. These projects build upon the skills learned in core and professional elective courses taken by the students in previous years. It would be beneficial to increase the number of professional electives courses with laboratory components and/or stand-alone laboratory courses from each of the sub-disciplines to provide an opportunity for students not enrolled the Thesis Course (CHY40) to reach proficiency in laboratory skills in sub-disciplines other than analytical chemistry.

Many of the laboratory components require students to work in groups and to share access to instrumentation with other groups in order to complete their assigned tasks (learning outcome 6). These skills are further reinforced in upper level courses through in-class exercises and presentations that require students to explain and defend their solutions to problems, compose term papers and/or give oral presentations on current topics from scientific literature.

Co-op students who are able to complete all 5 work terms prior to the beginning of their final year of study are able to reach proficiency in program learning outcomes 2-8.

Students with an interest in Inorganic Chemistry can apply to participate in the Inorganic Chemistry Exchange (ICE) program, which offers summer employment opportunities.

k) Student Assessment

All of the program learning outcomes and all of the UDLEs are assessed by at least one form of evaluation in each of the required chemistry courses. While the first year chemistry courses rely quite heavily on multiple choice examinations for assessment, by third and fourth year, students are normally assessed through short answer tests, problem sets and assignments. Lab reports are *de rigueur* in courses with a laboratory component. The most common forms of assessment and the program learning outcomes and UDLES that they support are shown in Table 8. Other forms of assessment are used in some courses, such as oral presentations, term papers and case study.

Table 8 Support of Program Learning Outcomes and UDLEs by STUDENT ASSESSMENTS in Required Chemistry Courses

Assessment Method	Program Learning Outcome (s)	UDLE(s)
Midterm exams	1, 2, 3, 4A, 4B, 5, 6A, 6B, 7A, 7B, 8A, 8B	1-6 (all)
Final exams	1, 2, 3, 4A, 4B, 5, 6A, 6B, 7A, 7B, 8A, 8B	1-6 (all)
Problem Sets	1, 2, 3, 5, 6A, 6B, 7A, 7B, 8A	1-6 (all)
Assignments	1, 2, 5, 6A, 6B, 7A, 7B, 8A, 8B	1-6 (all)
Lab report(s)	1, 2, 3, 4A, 4B, 5, 6A, 6B, 7A, 7B, 8A, 8B	1-6 (all)

l) Student Success and Achievement

About 76% of the students who entered the Chemistry program have been retained in the second year of the program. The number of students entering second year in the Chemistry program with clear standing has varied from 37% to 61%, with an average of about 53%. These values are similar to the overall figures for the Faculty of Engineering, Architecture and Science, the program's home faculty from 2005-1012, but lower than for Ryerson as a whole.

The retention data indicate that of entering students, 65% have entered third year of the program and 60% have entered fourth year. These figures indicate that while students have the most difficulty adjusting to the first year of the program, they are likely to continue in the program. Only a handful of students do not make it from second year to third year; these are most likely to be students who experienced academic difficulties in their first year of the program. The retention figures for students after two and three years in the program are comparable to those for students in the Faculty of Engineering, Architecture and Science, but somewhat lower than those for Ryerson as a whole. This is a reflection of differences between science and engineering programs and other programs at Ryerson.

Since the Chemistry program was launched in 2005, there is insufficient data available to comment on the graduation rates of newly-admitted secondary school students within six years.

Academic Standing Distributions are similar to those for the science programs within the Faculty of Engineering, Architecture and Science for all four years of study. Science students typically have the most difficulty in the first year of study, which is reflected in the lower proportion of clear students after first year in science compared to Ryerson as a whole. The academic standing distributions for third and fourth year chemistry and science students are in line with the distributions for Ryerson. Graduating students have a mean GPA of approximately 3.0, which is consistent with both the sciences and Ryerson.

m) Library Resources

The Ryerson library chemistry collection currently includes content and resources from SciFinder Scholar, Scholars Portal Journals, Scopus, Science Direct, the Royal Society of Chemistry, and Compendex. The library is well poised to support Chemistry students.

Maintaining access to the ACS journals is of utmost importance for continued research and teaching in chemistry. CRKN (Canadian Research Knowledge Network) recently negotiated a new contract with ACS that extends the terms and pricing of the existing contract for two years, with an annual increase applied. Chemistry students use and access not only the chemistry collections, but collections in other areas as well. Besides electronic and print materials, the library also has other resources available for students, in particular, the Math Assistance Centre and the Writing Centre, both of which are used by Chemistry students. The library also offers some technology and reference support.

n) Student Surveys, Focus Groups, and Graduate Surveys

Students of the Chemistry program indicate a general level of satisfaction with the quality of the program. Current students agreed and strongly agreed that:

- the program is academically challenging (95%; N = 82)
- the program is of high quality (84%; N = 83)
- most professors are current and knowledgeable in their field (82%; N = 83)
- most professor's teaching is intellectually challenging (78%; N = 82)
- the content in the program courses is well organized (77%, N=83)
- the teaching experienced is generally of high quality (72%; N = 69)
- the program provides good preparation for a career (61%, N=83)

In the NSEE 2011 results, 82% of third year chemistry program NSSE respondents (N=17) indicated that their entire educational experience at Ryerson was good or excellent.

Overall, students reported that the program helped them to improve at least somewhat in a variety of skills.

- 66% of current students reported that the program improved their ability in problem-solving and critical thinking very much or greatly
- 60% of the students believe that the program has improved their research skills very much or greatly

- 66% improved their ability to work in teams very much or greatly by being in the program
- Students also reported improvement in their oral and written communication skills, leadership skills, computer proficiency, understanding their professional or ethical responsibilities, employment related skills and knowledge, and knowledge of their career field.

Students indicated the contribution of different aspects of the program to their learning. In particular, students found the following to be effective:

- computer-based library resources (78%, N=83)
- written assignments (77%, N=83)
- laboratory experiences (77%, N=83)
- group work (72%, N=83)
- textbooks and other learning materials (71%, N=83)
- tests and examinations (69%, N=83)
- classroom instruction (68%, N=83)

NSEE 2011 responses suggest that in the first year of study, much of the emphasis is on memorization and analyzing basic ideas, but not so much on synthesizing information or ideas, or on making judgements, or applying knowledge. By the time Chemistry program students reach their fourth year, the emphasis on memorization has dropped and is replaced by synthesizing and organizing ideas, information and experiences. The emphasis on evaluating information, arguments or methods, or on applying theories or concepts to practical problems or new situations does not increase from the levels reported by first year students, and in both cases are well below the values reported by students in the Faculty of Engineering, Architecture and Science.

Further evidence comes from the NSSE scores for the institutional contribution to solving complex real-world problems. These score suggest that instructors should make an effort to link classroom activities more closely with real-world problems, and to provide upper year students with more complex problems.

From 2009-2012 there were 72 BSc Chemistry graduates. With only four respondents to the *alumni survey*, the errors are likely to be very high. All four respondents reported that they would recommend Ryerson. In addition, the respondents indicated that they were either very satisfied (33%) or satisfied (67%) with the overall quality of education they received at Ryerson.

Using a variety of sources (Facebook™, LinkedIn™, alumni emails, and personal knowledge), we have managed to obtain incomplete data regarding pursuit of additional education and current employment from 51 alumni. The results are summarized below:

- 30 of the 51 alumni pursued some form of additional education after graduating from Ryerson.
- Of the 30 alumni who pursued additional education, 20 pursued an MSc or PhD, with 12 of the 20 alumni doing their graduate studies at Ryerson. The second most common form of additional education was a BEd degree (5 students). Other forms included training at colleges and professional schools such as medicine.
- Of the 51 alumni we collected data from, 12 are currently employed in industries directly related to chemistry and/or science. There are also several alumni who could be considered ‘in transition’ and are employed as Research Assistants or working with science outreach programs such as Visions of Science while they consider their future career paths.
- Approximately 12 alumni are currently employed in other areas. Examples include the financial sector (3), communications, law related areas, and the service industry.

Results from the *employer survey* (N=4) indicated that employers of graduates of the Chemistry program are satisfied or very satisfied with our graduates skills and abilities in technical skills, written and oral communication, ability to plan and run projects, organization, initiative, creativity, leadership potential and overall quality of work. For these categories, the employers indicated that Ryerson graduates are better or comparable to graduates of similar programs at other universities. The respondents indicated that they would prefer graduates with a degree in chemistry, and were evenly split between wanting graduates who had specialized in-depth knowledge of chemistry, and graduates who had a breadth of knowledge in many disciplines. Mathematics and Computer Science are the two areas of science of most interest as secondary areas of knowledge in chemistry graduates.

While the employers indicated some dissatisfaction with graduates' skills at data analysis and problem solving, they also indicated that our graduates were ranked as better or comparable to graduates from other universities at data analysis and problem solving.

6. ACADEMIC QUALITY INDICATOR ANALYSIS

a) Faculty Qualifications

The core chemistry faculty includes all the chemists in the Department of Chemistry and Biology. Faculty members from other disciplines and departments are also involved in teaching the required courses in biology, communication, computer science, mathematics, and physics. Almost all the chemistry faculty have PhDs in chemistry, and most also had postdoctoral experience prior to joining the faculty at Ryerson. Several of the faculty members also have professional experience outside of academia.

b) Scholarly, Research and Creative Activities

Chemistry research within the Department of Chemistry and Biology has a number of foci: synthesis, materials, chemical education, and environment.

Undergraduate students have the opportunity to participate with SRC activity within the department in a number of ways. Students in their fourth year of the program can pursue a research project in one of the research laboratories or a chemical education research project under the supervision of a faculty member. Between 2009 and 2012, 54 chemistry undergraduates have taken the chemistry research project course (CHY 40A/B), 21 of whom are known to have entered graduate school, and five to have entered teacher's college. Some of the research laboratories are able to hire students to work as research associates during the summer or as Co-operative education work terms. In addition, some students volunteer to work in the research laboratories. Research activities and the results of research studies are discussed in classes when this work is relevant to the topics under discussion.

The Ryerson University Analytical Centre (RUAC), a department-run facility, supports some of the analytical work related to SRC activities in the department. The Department also houses a Tissue Culture facility within a clean room, and an Advanced Microscopy Facility.

c) Admission Requirements

Eligibility for admission to the Chemistry program is on the basis of an Ontario Secondary School Diploma with a minimum overall average of 70% in six Grade 12U/M courses including Grade 12U English (ENG4U/EAE4U preferred), Advanced Functions (MHF4U), and two of Biology (SBI4U), Chemistry (SCH4U) or Physics (SPH4U). Students applying for admission to the Chemistry program are strongly recommended to have SCH4U; SBI4U and SPH4U are also recommended. These admissions requirements are similar to those of many chemistry programs in the province.

d) Student Qualifications

Students entering into the Chemistry program between 2005 and 2011 had mean entering averages between 77 and 78% based on their best six Grade 12U courses (Table 9).

Table 9: Entering Averages	Year						
	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Ryerson	78.8	79.8	80.2	80.6	81.5	81.4	81.9
Engineering Architecture & Science	77.7	78.5	78.4	79.3	79.8	80.1	-
Engineering and Architectural Science	-	-	-	-	-	-	82.4
Science[1]	75.0	76.6	76.6	76.6	77.8	77.3	77.9
Chemistry	**74.8**	**79.9**	**76.5**	**76.2**	**79.7**	**76.6**	**77.7**

The percentage of students with entering averages over 80% in the chemistry program tends to be lower than for the Faculty of Engineering, Architecture & Science or the University, but this value is on average similar to the value for the science programs (Table 10).

Table 10: Entering Averages Over 80% (percentage)	Year						
	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Ryerson	41.3	48.4	52.2	55.1	61.7	61.6	66.0
Engineering Architecture & Science	32.3	38.5	36.6	42.8	48.1	48.8	-
Engineering and Architectural Science	-	-	-	-	-	-	68.5
Science[1]	12.5	26.9	21.5	27.3	30.7	25.1	30.9
Chemistry	**4.0**	**40.0**	**22.6**	**3.0**	**48.4**	**24.4**	**27.0**

e) Enrolment, Retention and Graduation Data

The chemistry program has met its enrolment targets each year since the first admissions into the program (Fall 2005). This is due in part to the ratio of applicants for each spot in the program which has never dropped below than 10:1.

Retention data for the Chemistry program (Table 11) indicate that retention of newly admitted chemistry students in the chemistry program is comparable to retention in other science and engineering programs, although lower than in other programs at the university. Other years show mixed results.

Table 11	**% Retained in same program after 1 year**						
	Fall 2005	Fall 2006	Fall 2007	Fall 2008	Fall 2009	Fall 2010	Fall 2011
Ryerson	81.0	81.3	82.1	80.0	81.0	82.3	82.1
FEAS	75.6	77.4	74.7	73.4	74.2	-	-
Science	-	-	-	-	-	73.5	72.0
Chemistry	**85.3**	**82.4**	**69.1**	**75.8**	**73.0**	**71.7**	**66.7**

Table 12	**% Retained in same program after 2 years**						
	Fall 2005	Fall 2006	Fall 2007	Fall 2008	Fall 2009	Fall 2010	Fall 2011
Ryerson	70.2	74.8	75.3	72.9	75.9	74.3	-
FEAS	62.6	69.2	65.5	60.3	-	-	-
Science	-	-	-	-	66.9	66.3	-
Chemistry	**67.6**	**73.5**	**54.8**	**69.7**	**59.5**	**69.6**	-

Table 13	**% Retained in same program after 3 years**						
	Fall 2005	Fall 2006	Fall 2007	Fall 2008	Fall 2009	Fall 2010	Fall 2011
Ryerson	65.9	71.3	70.3	70.4	69.9	-	-
FEAS	59.1	64.8	59.5	-	-	-	-
Science	-	-	-	56.6	58.3	-	-
Chemistry	**58.8**	**58.8**	**52.4**	**69.7**	**45.9**	-	-

Of the newly admitted secondary students who entered the Chemistry program in Fall 2005, 59% had graduated within six years. This is better than the average for 2005 cohort in the science programs (48%), although slightly lower than for engineering and architecture programs (66%) or the university average (66%). On average, students in the Chemistry program are registered for 9.7 academic terms. This is equivalent to 4-5 years of study for most students.

f) Additional Program Feedback

The Chemistry Advisory Committee provided input regarding the strengths and opportunities of our program in light of the current and projected job opportunities for chemists in Canada. They suggested that 40-50% of the jobs will be in analytical chemistry (QA, QC, support), 15-20% in synthesis and process development, and the remaining 30-45% in product development. Overall, the advisory committee likes the direction of our current program.

- The focus in analytical chemistry is a strength and an important differentiator. The advisory committee thought that we should not sacrifice our strengths in analytical chemistry instruction in order to build strength in other areas.
- The chromatography course (CHY 331) is one that is not usually found in chemistry curricula. However, the advisory committee thought that this course is key for our students for entry into the industrial workplace, and would be even more important for this if more real-world connections and relevance were included in the course.
- If any changes are to be made to the analytical chemistry component of the curriculum, the committee suggested that the curriculum should be modernized and that the emphasis on titrimetric and gravimetric techniques in Analytical Chemistry I (CHY 213) be reduced in both the lecture and laboratory components and that a wider variety of techniques be taught here instead.
- To make students market-ready, they should be introduced to, and taught, industrial lingo, process control and organizational structure and roles.
- Students should have many opportunities to develop written and oral communication skills appropriate to the discipline, including the use of graphics to illustrate ideas and concepts clearly.
- The use of statistical tools, such as SPSS, to determine the relevance of data is a numeracy skill that is also of importance and should be well developed by the time students graduate.
- Although there is value in being able to work with others, it is important that all employees are able to work independently and be accountable for their contributions to their team. In most cases, teams are comprised of members from different disciplines, so it is vital that team members are able to collaborate with others across disciplines. Some knowledge of these other disciplines is useful.
- Students should have an understanding of copyright and trademarks. They should know how to use and research ChemAbstracts as is already done with the thesis students. Teaching aspects of regulatory science would increase the market-readiness of our students upon graduation.

7. RESOURCES

a) Faculty and Staff

The Department of Chemistry and Biology administers the Chemistry program, the Biology program and the Biomedical Science program (F2013). The Department has a Departmental Chair, a Program Director, and Co-Operative Education Coordinator, all of whom are chemists. The Associate Chair is the Biology Program Director.

The Department of Chemistry and Biology is supported by an Administrative Coordinator, and two Departmental Assistants. Another staff member provides additional administrative research support and program coordination for the graduate programs in Molecular Science. The Chemistry program has three technologists to support the running of teaching laboratories and equipment, as well as the Ryerson University Analytical Centre (RUAC), and overseeing safety.

The Advisory Council consists of six individuals who have an interest in undergraduate chemistry education. In selecting members for the advisory committee, representation from both industry and academia, and from different sub-disciplinary foci was sought.

Full-time faculty (RFA) teach 72-92% of the chemistry courses offered by the Department of Chemistry and Biology. The faculty strength is in synthetic and materials chemistry (inorganic and organic). Therefore, we are well equipped to teach inorganic chemistry, organic chemistry, and general chemistry with our current faculty complement. However, we are currently weak in physical chemistry and analytical chemistry due to administrative positions. A bioorganic or biological chemist would help to expand our offerings into the well-established cross-disciplinary area of chemical biology.

We currently have 29-35 TA/GA chemistry positions and 3-4 marking assistants. Teaching assistants for chemistry courses are normally selected from among the graduate students in the Molecular Science and Environmental Applied Science and Management programs pursuing work under the direction of members of the department.

b) Curriculum Counseling/Advising

Students with questions or who want advising regarding their course selections are directed to the Program Director, who provides advice based on the student's advisement report, transcript, program requirements, and the student's strengths, current and post-graduation interests. Those wishing assistance with career choice and development normally seek advice from the Program Director or any of the other faculty members. Additional resources are available from the Centre for Student Development & Counselling and from the Career Development and Employment Centre.

The First Year and Common Science Office (FYCSO) plays an active academic advising role to all first year students register in programs within the Faculty of Science, including those registered in the Chemistry program. The FYCSO collaborates with student groups in the organization of Orientation Activities prior to the start of the Fall semester and is the official academic home department of the online SCI180 Orientation course designed to help familiarize incoming students with the academic policies and support structures provided by Ryerson University. The FYCSO coordinates with Student Learning Support to ensure that appropriate services are available for first year science students.

c) Physical Resources

Chemistry and Biology largely resides in the north-east corner of Kerr Hall on the second and third floors. The Department has a total of 8895 ft2 of chemistry teaching lab space, with an additional 955 ft2 of preparatory space. The research labs total 4499 ft2. While some of the laboratory space has been completely renovated since 2000 and is in relatively good shape, most of this space is antiquated and in need of renovation.

The Department has no dedicated computing facilities. Students have access to academic computing laboratories distributed across Ryerson University and wireless access to Ryerson's central portal is possible throughout most of the Department's space.

8. STRENGTHS, WEAKNESSES AND OPPORTUNITIES

a) Strengths

- The Chemistry program has managed to keep the feeling of a fairly small program, despite the high student to faculty ratio.
- Although the first year classes are relatively large at 300+ students, these are still smaller than corresponding courses at nearby universities.
- Faculty are relatively accessible to students, are approachable and friendly.
- The chemistry program gives students many opportunities for experiential learning.

- Most chemistry courses are taught by full-time faculty.
- Most faculty pursue funded research activities in their areas of expertise.
- The department has a relatively high proportion of faculty (3 of 12) who are actively involved in chemical education research activities, as well as others who are interested and dabble in this field.
- Most of the program learning outcomes are met through the required courses and emphasized through the professional and professionally-related courses that students choose in their upper years.
- Students and alumni value the chemistry program and would recommend it to others. Employers are satisfied with the quality of our graduates.

b) Weaknesses

- Analytical chemistry is emphasized compared to other areas of chemistry in the current chemistry program. This emphasis is a product of the history of the Chemistry program and the Department, but is not consistent with current faculty strengths in inorganic, organic, synthetic, polymer, and materials chemistry. In addition, this emphasis is not consistent with the learning outcomes and interests of many of the chemistry students.
- The learning outcome of knowledge in chemistry is not well met through the current courses. In order to address this, several new courses will be developed, and some existing courses will be redeveloped.
- While the Chemistry program currently meets the chemistry course instructional requirements for CSC accreditation, the program would be stronger if students were required to take additional chemistry courses beyond the number they currently take (17). Comparison with our comparator programs suggests that three additional courses would be needed.
- The Chemistry – Applied Physics Option program is not accredited by the CSC, and has relatively low student enrolment. Students enrolled in this program complain that there is too much overlap between some of the required courses. In addition, they find that many of the physics courses that are part of the program are too focused on medical physics; they would prefer courses in classical physics, quantum physics and chemical physics.
- Many of the undergraduate laboratories are out-dated and/or lack the equipment for modern analysis techniques. Some of the equipment has come to the end of its functional life and can no longer be repaired. Funds to replace needed equipment and to maintain this equipment are not readily available. Some of the laboratories have been renovated while others have not and are in need of renewal. The Chemistry laboratories are used to maximal capacity within the capabilities of the Chemistry department, the equipment available, and scheduling (timetabling).
- While the quality of TA/GAs is a concern, we are confident that the overall quality of TAs is increasing. We provide TAs with more training now through the Learning and Teaching Office than we used to, and also provide them with feedback and resources. As the need for additional sections of chemistry laboratories increases, we expect to have increasing difficulty filling these positions.

c) Opportunities

- Faculty research interests in synthetic, inorganic, organic, materials and polymer chemistry could be capitalized upon to develop new professional courses and the possibility of allowing students to pursue areas of concentration within chemistry.
- Opening up the program structure would provide students with more choice of courses and also more opportunities to take the professional courses (chemistry electives) that are of most interest to them and that will provide them with the best preparation for future endeavours, including employment and graduate studies.
- There is no BSc in Environmental Science, although the Biology program does have an Environmental stream. We would be interested in contributing towards the development of a BSc in Environmental Sustainability.

- Growth in the Faculty of Science has seen increasing numbers of faculty who pursue biochemical research. The expected new hires for the Biomedical Science program are expected to strengthen this area even further. Some of this work contributes well toward the field of Biological Chemistry, which could be expanded beyond a proposed area of concentration under the BSc Chemistry into a program of its own.
- The possibility of having a new building to house the Faculty of Science is very exciting. This new building will not only allow the faculty to rectify a serious space deficit, it will also provide an opportunity to design flexible multi-purpose chemistry teaching laboratories and new research laboratories with adequate space for equipment and research activities.
- An interesting curricular opportunity is to programmatically address deficiencies in the training provided by college programs and local competitor universities by meeting a middle ground between these types of training, balancing communication skills and rigorous academic preparation and communication skills with practical hands-on knowledge.

9. DEVELOPMENTAL PLAN

a) Curriculum

Curricular development in the Chemistry Program is needed to provide students more choices in their third and fourth years, and to strengthen the core chemistry program while maintaining current strength in analytical chemistry.

Year 1 Development (2014-2015)

The core concepts and skills should be identified and mapped throughout the program. This will address the deficiencies in program learning outcome 1 (knowledge) that we noted in our program mapping. This mapping should provide indications of areas of redundancy and weakness. Redundancies should be removed, and weaknesses addressed by including instruction in those areas. The mapping would also track and programmatically address differentiation from other university Chemistry Programs. Renewal of the Chemistry Program accreditation will be sought.

Year 2 Development (2015-2016)

Course content, outlines and descriptions should be adjusted according to the results of the concept and skill mapping. New courses may be created and existing courses could be repositioned in the program. Student advising documents will be created to help students choose their professional elective courses and navigate through a series of program concentrations (e.g. Analytical, Industrial, Synthetic, Biochemical, Physical, etc.). As part of a process of opening up the program to allow students to specialize in concentrations or to broaden their horizons with minors, we would like to create room for six open electives.

Year 3 Development (2016-2017)

Program changes will begin to be rolled out, the success of the program will be monitored and adjustments made as required. In addition, we anticipate the formation of a formal mentoring system for Chemistry Program students.

Renewal of the Chemistry - Applied Physics Program

- Discuss alternative physics courses; students would prefer traditional and quantum chemistry courses rather than medical physics courses.
- Determine how to make the program acceptable for accreditation.
- Determine if the program should be cancelled due to low student enrolment and the results of our discussions with the Department of Physics, and how easy or difficult bringing the program in line with accreditation guidelines proves to be. This program could in effect be replaced by a “Physical Chemistry” concentration.

b) Personnel

One faculty hire in 2014-2015 has been agreed upon at the Faculty level and is linked to the staffing needs associated with the newly launched Biomedical Science program. Teaching needs related to this program call for hiring an organic chemist, although the needs of the Chemistry program call for hiring an analytical chemist. The major challenge with hiring a new faculty member is that space will be required for an office for the faculty member, and the faculty member will need his/her own laboratory research space. We currently need additional laboratory space in our existing organic laboratories.

c) Equipment

Adopting a systematic approach to equipment inventory and maintenance remains a Faculty of Science priority and a work in progress.

10. SUPPLEMENTAL DEVELOPMENTAL PLAN (May 2015)

Year 1 Development (2015-2016)

a) Mapping of core concepts and skills.

b) Analysis of entrance requirements.

c) The first year experience:

- perform data analytics to identify the risk factors which may lead to students experiencing academic difficulties during the first year of their program (including high school performance in science and math courses in addition to the overall average, and the number and combination of math and science courses taken in highs school).
- identify curricular bottlenecks in each of the Science programs to ensure that the content of such courses is relevant to the program and that appropriate support services are put in places for students taking these courses to provide the greatest opportunity for student success.
- establish a pilot project in cohort registration which will see the incoming class of Fall 2015 chemistry students assigned to common lecture and laboratory sections of required first year courses.

d) Co-operative education option – the Department will work with the Office of Co-Operative Education to determine if the number of required work terms should be decreased to bring it into alignment with newer Co-Op programs offered at the University.

Year 2 and 3 Development (2016-2018)

a) Concept map flow chart – following mapping of the core concepts and skills through the program, this information will be compiled into a flow chart or concept map that shows how the concepts are threaded through the program.

b) Communication skills rubric –the descriptors in this rubric could be extended to cover the first and second year student level as well as graduate student writing.

c) Admissions requirements will be re-evaluated based on the information provided by the study carried out by FYCSO. Changes to consider will be the required courses and minimum grades. We will begin to monitor the impact of changes to the admissions process and requirements.

d) Analytical Chemistry – the lecture and laboratory content of the analytical chemistry stream (CHY 213, CHY 223, and CHY 330) will be analyzed and re-worked to modernize this stream and to remove redundancies. We will submit new analytical chemistry courses for approval by ASC and inclusion in the course calendar.

e) Quantum physics – the required quantum physics course will be revised and combined with computational chemistry to make a course that is more relevant to chemistry students than the existing course. Computational and Quantum Chemistry will replace PCS 400 as a required course in the curriculum. We will monitor the impact this has on students.

Ongoing

a) Renewal of laboratory experiments – new experiments for all laboratories will be developed to provide students with more input into the direction of the work they undertake in the laboratories, and also to provide more real-world types of experiences within our operational constraints.

11. PEER REVIEW TEAM REPORT

1. Outline of the Visit

The Program Review Team (PRT) was composed of Dr. Robert Burk, Department of Chemistry, Carleton University; Dr. John Honek, Department of Chemistry, University of Waterloo; and Dr. Mehrab Mehrvar, Department of Chemical Engineering, Ryerson University.

The PRT visited the Department of Chemistry at Ryerson University on October 27th and 28th, 2014. The PRT had the opportunity to meet with the Chemistry Program Director, the Department of Biology and Chemistry Chair, the Vice Provost Academic, the Associate Dean, Research & Graduate Studies, the Chemistry Academic Coordinator, three faculty members, a Technical Specialist, the Departmental administrative staff, (6) undergraduate students (all years); and graduate students (3), (4-5) recent graduates (alumni) of the BSc program, an Advisory Council Member, the Faculty of Science Dean, and the Provost & Vice President Academic. The PRT also observed a high school outreach experimental lab being performed while on their visit.

A range of laboratories (undergraduate as well as research) was seen by the PRT. In addition, several centralized analysis facilities were also visited. Several undergraduate classrooms were also briefly seen by the PRT. One of the external reviewers (JH) took a self-guided tour of the Ryerson University library. The committee also had several opportunities to walk through the Ryerson campus to capture a sense of the spirit of Ryerson.

2. General Overview

Based on these documents and the site visit, the following areas of the undergraduate Chemistry program are considered strong:

- A strong curriculum which has evolved over the years to accommodate new areas of modern Chemistry such as Materials Science and advanced qualitative and quantitative instrumental analyses, while continuing the strong tradition of Ryerson's involvement in training technologists
- A desire by faculty and staff to provide students with outstanding "real world" opportunities and to provide an intimate atmosphere for learning. This was clearly evident in the PRT's discussions with faculty, staff and students (current undergraduate, graduate and alumni).
- Creative use of external business expertise by developing an advisory committee to the department. This type of committee is rarely seen at universities, so this was a very positive aspect to the Chemistry program different from other Chemistry programs in Canada.
- Creative sharing of undergraduate and research equipment and facilities to the benefit of both the undergraduate program and the graduate/research programs of members of the Chemistry Department.
- High school student outreach in the form of research experience provided to high schools was viewed as positive and creative, especially since that type of interaction would likely provide community support for the Faculty of Science and the University.
- The presence of new faculty members as well as established faculty members that provide for a very positive student environment. Interviewed students were highly complementary to the faculty and staff in the department and repeatedly confirmed the positive learning environment that was present in the department.
- The Department of Chemistry and Biology has self-identified eight key strengths in research capacity. It is expected that the expertise available in these areas would benefit undergraduate students by providing them summer research opportunities and/or 4th year research project opportunities.

3. Feedback on Evaluation Criteria

a) Objectives (alignment with institution's plans)

Consistency with the institution's mission and academic plans and with the program's academic plan

The PRT believes that the Chemistry Program is consistent with the institution's mission and academic plans and with the Faculty's academic plan. During the interviews, current program students as well as alumni clearly stated that the Chemistry program is rewarding, the program is applied based with hands-on experience in laboratories, and also the faculty members are very approachable. In addition, students have the opportunities to conduct a research project by taking CHY 40A/B (Research Project-Thesis) in order to enhance their research and scholarly skills. Also, students have the option of taking co-op to gain industrial experience. This clearly aligns with the training of highly skilled professionals for the societal needs.

Program requirements and learning outcomes clear, appropriate and in alignment with the institution's statement of undergraduate and/or graduate Degree Level Expectations

The Undergraduate Degree-level expectations (DLEs) specify six areas of ability required at the undergraduate level. These areas include: Depths and Breadth of Knowledge, Knowledge of Methodologies, Application of Knowledge, Communication Skills, Awareness of Limits of Knowledge, and Autonomy and Professional Capacity. The learning objectives (goals) are very well implemented in the program. However, through the interview with the students and alumni it was discovered that the students need more attention in communication skills.

The PRT strongly believes that the learning outcomes of the Chemistry program are well addressed through different levels of courses. However, the PRT recommends to offer more professionally related chemistry courses from Table 1. If these professionally related chemistry courses are more frequently offered, students will be prepared more to enter the professionally related job markets. Due to the need for statistical analysis of data in laboratory experiments, the PRT suggests to move MTH 380 (Probability and Statistics I) to earlier semesters or to blend most of the important contents of this course to Analytical Chemistry I in case of its elimination.

b) Admission Requirements

Admission requirements appropriately aligned with the learning outcomes established for completion of the program

The PRT understands there are legacy issues in the Department that partly dictate the admission requirements. In particular, the original desire to have a common set of courses for all first year students in Science is one reason for demanding only two of the three 4U-level science courses in high school. Regardless of the reason, this practice is common at other Ontario universities. However, three items are worth considering:

1. The high school Calculus and Vectors course is not an admission requirement. It may be worthwhile to at least "strongly recommend" that they take it.
2. Chemistry SCH4U is "strongly recommended" but not an admissions requirement. This is a curious point - the course is required by most Ontario university chemistry programs, either as a program requirement or as a prerequisite for first year chemistry courses. Ryerson may want to consider making the course mandatory, or possibly creating a remedial high school-level course prior to students entering CHY 103.
3. A grade requirement of 65-70% is rather low and may be contributing to low retention rates in the chemistry program. In the 2010-11 year (the latest year for which data were made available to the PRT), only 19 of 51 first year students were "clear". A further 16 were placed on probation and 16 more were required to withdraw. This is a very low success rate in first year. Not having a solid grounding in high school chemistry and calculus, or having low high school grades cannot be a good thing for students

entering an undergraduate chemistry program. The chemistry program itself is of good quality and Ryerson therefore ought to be competing with other institutions for the best students in the province.

c) Curriculum

The curriculum reflects the current state of the discipline or area of study

The required courses in Ryerson's Chemistry program are typical in Canadian universities. Areas covered include organic, analytical, physical, inorganic and biochemistry, as demanded by the accreditation process of the Canadian Society for Chemistry. Optional courses, although not numerous, also cover a range of modern topics such as environmental chemistry, food science, pharmaceutical chemistry, as well as materials, solid state, polymer and organometallic chemistry. If these optional courses are offered frequently enough, an undergraduate student will graduate with an appreciation of the current state of chemistry. There were concerns raised by students however, that such courses are not offered frequently enough that they did not have much real choice of which courses to take.

Evidence of any significant innovation or creativity in the content and/or delivery of the program relative to other programs

The content of the program, including mandatory and optional courses, covers the main areas of chemistry, as described above. The number of faculty members and their areas of expertise largely dictate the breadth of content, so it seems unlikely that this will increase significantly in the near future.

In the words of the self-study, "The Chemistry program is delivered in a traditional manner." This means that the lectures and tutorials are delivered live, in classrooms, to the students. Laboratories are regularly scheduled in most courses and again are delivered in a traditional manner, i.e. in a real laboratory. As such, the PRT was not made aware of any particular innovative teaching methods. However, there is nothing wrong with traditional methods. Especially for the relatively small class sizes in this program, the face to face Socratic method works very well.

The modes of delivery are appropriate and effective to meet with the program's identified learning outcomes

The modes of delivery used in this program vary from traditional lectures to lectures including demonstrations, as well as discussions, tutorials and other in-class activities and exercises. Many of these activities include some group work and collaborative or cooperative learning. In each case, teaching via these methods is introduced in the lower level courses, reinforced in mid-year courses, and students become proficient learners using these techniques in senior year courses. All of the program goals are appropriately mapped to these modes of delivery, in both the core chemistry courses and the other courses such as physics, computer science, etc.

Particularly noteworthy is the large number of courses, even in the senior years, that include a laboratory component. This is a feature of Ryerson's chemistry program that should be protected and nurtured in the face of cost-cutting measures that are surely biting at its heels. Ryerson's history of teaching applied chemistry should be emphasized and used to advantage while recruiting, especially since the focus in Ryerson's labs these days is much more modern than decades ago. Delivering chemistry via laboratory work is chemists' version of experiential learning and is tied deeply to the learning outcomes.

d) Teaching and Assessment

The methods used to assess student achievement of the program learning outcomes and degree level expectations are appropriate and effective

It should be noted that Ryerson Chemistry Program is currently accredited by the Chemical Institute of Canada and the program is similar to other chemistry programs in Canada. For lecture-based courses, the standard approach is to require a combination of assignments, midterms and final examinations based on the course material, with questions that allow students to make use of learned materials and apply them to new problems. These are also goals that are present in the current Chemistry curriculum and are assessment criteria utilized throughout Canada as well. As stated in the Self Study Report, “the goals are intended to support a high-quality accredited program and to produce graduates with the appropriate knowledge and skills to solve problems, design and perform experiments safely and effectively, communicate clearly, work well with others, use resources effectively and demonstrate sound ethical conduct”.

Analysis of the documentation on individual courses provided to the PRT, which included listings of the assessment methods, indicated that various forms of student learning were present and took the form of the usual assignments (both in-class and take home), spot quizzes which could vary from short essays, short answer, to multiple choice formats. Learning objectives were clearly indicated for courses (based on the course outlines provided) and many outlines went into great detail to provide the important areas of understanding that a student was required to develop in that particular course. In addition, some courses indicated that students may be required to use spreadsheet programs to handle some course material. Experimental skills and learning, as exemplified through laboratory-based courses, were assessed in the standard fashion (experimental results reporting in short form and longer and more detailed “lab reports”).

Interestingly, students that were interviewed by the PRT during the site visit indicated that the students would like to see more information on how to write proper lab reports provided to them early in the term, and that example lab reports be available, so that they did not have to learn proper lab report writing by so much trial-and-error. The students requested that feedback on their lab reports were provided in a more timely fashion.

The PRT did notice that many courses have Experimental Design as an important learning objective. This is important. However it appeared to the committee that students would require the 4th year research project (CHY 40A/B) to become proficient with this aspect. Perhaps the departmental curriculum committee could identify courses that could provide more formal training in this in some way.

The means of assessment (particularly in the students’ final year of the program) are appropriate and effective to demonstrate achievement of the program learning outcomes and the degree level expectations
In addition to the standard approaches to student assessment mentioned above, which continue in many final year courses, the 4th year research project (CHY 40A/B) provides additional training at a high level. This laboratory course is a research project spread over two terms and is supervised by a faculty member, usually involving research in the faculty member’s laboratory. The course assessment is based on a combination of laboratory skills and effort, an oral presentation of the results obtained by the student and a thesis.

One worrisome aspect is that the enrolment in this course may be restricted by the number of available projects, and this is dependent upon availability of a) the faculty member and b) laboratory space and project for the student. It seemed that students that were unable to obtain a project to work on, would have to take other formal laboratory courses and miss out on the research experience. This course is a key course offering to students and provides an opportunity for graduating students to bring all their prior learning to focus on a chemical problem.

e) Resources
The appropriateness and effectiveness of the academic unit’s use of existing human, physical and financial resources in delivering its program. Also the appropriateness and effectiveness of academic services (e.g. library, co-op, technology, etc.) to support the program.
Although the resources in general have been aligned so far to offer two programs in Chemistry and Biology in the Department, there is an urgent need to increase most resources due to the growth of the Chemistry Program and the addition of the new Biomedical Science Program.

Currently, the faculty strength is in synthetic and materials chemistry (inorganic and organic). However, the program is currently low in the number of faculty in physical and analytical chemistry. The PRT suggests consideration to be given to the hiring of two more faculty members in physical and organic chemistry areas. The addition of a third faculty member in bioorganic or biological chemistry would help to expand the offerings into the well-established cross-disciplinary area of chemical biology.

With the addition of the Biomedical Science program in 2013, apparently the overall loads of the staff have been significantly increased. This will be more noticeable once there are biomedical science students from the first to the last year in the department. The PRT suggests to add at least one more office support staff to compensate the loads due to the growth of the department.

Although the current level of support is appropriate in delivering two programs of Chemistry and Biology, the addition of the Biomedical Science Program indicates the need of one more technologist. The addition of a Laboratory Coordinator would enhance the efficiency of the program in terms of delivery of the laboratory experiments, training teaching assistants, evaluation of students, etc..

There is a sufficient number of Teaching Assistants available to help in courses and laboratories. The PRT is impressed with the level of support coming from graduate students in terms of Teaching Assistantships. However, due to the current budget limitation of the department, the growth of the program, and the birth of the new Biomedical Science Program, a budget increase is necessary to make sure there is sufficient Teaching Assistantship support.

During the site visit, it was noticed that there is no space available in case of new faculty and or administrative hires. Students during the site visit indicated that they need a computer room along with common software and dedicated printers. However, the PRT is pleased to hear from both the Dean of Science and the Provost and Vice President-Academic that the new Faculty of Science Building is the university's first priority upon the availability of the budget for expansion.

During the site visit, it was noticed that recently some of the laboratories have been either completely or partially renovated. Although most of research laboratories are new and modern, most of undergraduate chemistry teaching laboratories are antiquated and in need of full renovation, both in terms of infrastructure such as walls, ceilings, fume hoods, etc. and in terms of benches and even some equipment. There are some serious safety issues related to the number and positioning of fume hoods, i.e. air quality.

The PRT is very pleased to hear about the construction of the new science building, the University's first priority, by which the laboratory space issues will be eventually resolved. In the meantime, however, undergraduate students are working in outdated and less than optimal space. These laboratories do not show well, and so are likely having a negative impact on recruiting the numbers and quality of students that the program deserves to have.

The library resources are well poised to support students in the Chemistry Program and courses. This is mainly due to the well-equipped services offered by the Ryerson library in terms of chemistry collections, both electronic and print materials. Titles not available at the Ryerson library either electronically or in print are accessible through the Interlibrary Loan Service, which is free to the Ryerson community. The PRT is pleased with the services offered by Ryerson Library to students. However, based on the self-study report, the book budget has been reduced to maintain some subscriptions. The PRT strongly suggests to Ryerson Library to add new titles related to chemistry continuously and also to increase the library budget to make sure all related chemistry titles are available in print or in electronic form.

f) Quality Indicators

The outcome measures of student performance and achievement for the program

The program outcomes are clearly articulated in the self-study, and are appropriate for an undergraduate chemistry program. Measurements of student performance in each of these areas are made according to assessment methods that are also laid out in detail, and are mapped to the learning outcomes in each course. The grades attained by students are therefore reflective of their performance and achievement for the program.

The qualifications, research and scholarly record, class sizes, % of classes taught by permanent or non-permanent (contract) faculty; the number of part-time/temporary faculty and their qualifications and assignments

All faculty members in the chemistry department hold PhD degrees. There is a distribution of positions from assistant/associate professor to full professor. Two faculty members are currently in administrative positions outside of the department, which surely impacts both teaching and research productivity.

The CVs indicate a diversity of research interests, which cover the main areas of chemistry. The number of currently funded researchers is low however, and severely limits the amount of research taking place in the department.

Class sizes are predictably larger in first year, but only 6 chemistry courses have more than 250 students and only 15 have between 101 and 250 students. These are small introductory courses, compared to those in most other undergraduate chemistry programs in the province.

In the current year, the department is employing only 5 sessionals lecturers in the fall and 6 in the winter. This is quite a low number, especially considering there are several faculty on leave of some sort, and two in administrative positions outside the department. This translates into approximately 80% of courses being taught by FTF, which is quite acceptable.

Students: applications and registrations, attrition rates, times-to-completion, final year academic achievement, graduation rates, academic awards

The data tables provide many insights into applications, registrations, attrition rates, and so on. Some interesting facts, possible interpretations and unanswered questions are as follows:

- There are from 10-12 applicants per registrant in the chemistry program, which is somewhat higher than the average at Ryerson. Undoubtedly many students are repelled by the museum-like undergraduate laboratories in Kerr Hall, or at least attracted to the state of the art undergraduate laboratories at other nearby institutions.
- The average entrance grades are from 75-77%, somewhat lower than the Ryerson average, and there are far fewer entrants with average grades over 80% than in the rest of Ryerson. Increasing the average entrance grades is a slow process, but one that needs to be pursued. Entrance requirements may be a factor.
- There are essentially flat numbers of first year registrants (50-60) over the last few years, but significant growth in the total program numbers, i.e. transfers in after first year are significant.
- The planning projections indicate essentially flat projections. The reasons for these projections are not clear, considering steady growth (at least up to 2011).
- Almost 50% of the chemistry students at Ryerson are part time students. This may be a major factor explaining high attrition rates. If the part-time students are also more prone to being placed on probation or having to withdraw, again the entrance requirements may play a role in reducing these problems.
- The mean GPA upon graduation of chemistry students is approximately 3.0, which seems quite reasonable. In other words, those students who complete the program have good grades, which is important if they plan on doing graduate studies, for instance.

- Data for progress percentage of newly admitted secondary students who graduated within six years were only available for the year 2005, so no useful conclusions can be drawn. The self-study however indicates that students in the chemistry program are registered for approximately 5 academic years. This is reasonable, especially considering the large number of part-time students.
- No data were provided regarding academic awards.

Graduates: rates of graduation, employment after six months and two years after graduation, post graduate study, skills match alumni reports on program quality (if available and permitted by FIPPA)
No other data concerning these issues were available.

g) Quality Enhancement
Initiatives taken to enhance the quality of the program and the associated learning and teaching environment
The opportunity for students to take the 4th year research project is an important contribution to program enhancement. However, the availability of research space (and space in general) in the Chemistry Department for student projects does limit this initiative. As well, the number of faculty able to take on project students can be limiting.

The co-op stream could be an important initiative in enhancing the quality of the chemistry program at Ryerson. The co-op option for chemistry students does not seem to be as popular as in other universities. Perhaps the department and the university may wish to advertise this program more.

Initiatives to build a new Science building is an extremely important way to enhance the program. The availability of new laboratories and classrooms with data projectors would be most welcomed by faculty, staff and students and provide a better quality learning environment. The addition of a computer laboratory with printing facilities for chemistry/science students would also enhance the program.

The external advisory council is a very interesting and important strategic forum to enhance the chemistry program. Input from the advisory members could enhance the program by supplying an industrial view of needed training backgrounds and supply some real-world problems that could be shared with students.

4. Other Observations

- Students and alumni stated the faculty members are very approachable and they are quick in email communications.
- Students and alumni stated that the Chemistry Program is very rewarding.
- Students would like the department to invite one or two students who have done co-op to present their experience. This might serve in identifying future careers for students, networking connections and possible co-op opportunities.

5. Summary and Recommendations

Specific steps to be taken to improve the program, distinguishing between those the program can itself take and those that require external action
Several areas were identified by the PRT based on the documentation provided and the site visit meetings:

- It is highly recommend that additional course choices be available to 4th year undergraduate students that are relevant to their profession.
- Review of the content of some of the courses would be recommended. For example, the PRT found that some course materials and topics were repeated in various courses.
- An additional faculty hire would be recommended. The area that this hire could be in might be in the area of Biological Chemistry or Biomaterials, or in Physical Chemistry such as in Theoretical/Computational Chemistry.

- A new Science building should be given the topmost consideration by the University, and sufficient modern lab and lecture space for teaching and possibly research.
- Renovations of several of the current laboratories (research and undergraduate laboratories) that require them should also be actively pursued when possible.
- Additional space should be provided to undergraduate students in the form of lounge/study space for their use in the current building.
- Computer/printing facilities should be created in the department.
- Entrance requirements and hence entrance grades are rather low. This is a self-perpetuating problem unless steps are taken to raise both. Raising the entrance requirements and encouraging students with higher grades to attend (perhaps by offering more or better scholarships) may be a first step.
- Rates of attrition from the program are very high and need to be addressed, perhaps by recruiting better students as described above.
- The funded research done in the department is of excellent quality, but low quantity. This has the effect of limiting the number of students that can do summer research work, or take CHY 40 A/B. Future hirings must be done with the objective of raising the research profile of the department.
- With the addition of the Biomedical Science Program, it is recommended to have one additional office support staff.
- It is recommended to hire a laboratory coordinator for undergraduate chemistry laboratories.
- Improvement in soft skills for students. Although there currently is a communications course in the curriculum, a more science-centric communications course might be a better strategy for science students. A problems-based course that has students working on chemically-focused industrial problems could be another improvement.

12. RESPONSE OF THE DEPARTMENT OF CHEMISTRY AND BIOLOGY TO THE PEER REVIEW TEAM (PRT) REPORT

Overall, the PPR Report is highly supportive of the Chemistry Program. The PRT found that Chemistry has a strong, current curriculum that retains Ryerson's traditional values of applied, career-relevant education. Providing outstanding "real world" opportunities is a core aspiration of the program, ably supported by an advisory council with industry expertise. Newer and established faculty members collaborate to provide an intimate and very positive learning environment for students. The Department has been both creative and effective in maximizing the use of resources for delivery of undergraduate and graduate education and research. The Faculty of Science's high school student outreach activities in Chemistry was viewed as positive in raising Ryerson's community profile and strategic in supporting improved student quality.

The PRT found that the Chemistry program is consistent with Ryerson's mission and academic plans and the Faculty of Science's academic plan. Undergraduate Degree-level expectations are well implemented in the program and appropriately addressed at different levels of courses. The program is of good quality with typical coverage of the discipline, as would be expected from a program accredited by the Canadian Society for Chemistry. Although the program is traditional in its approach to curriculum delivery methods, and thus not particularly innovative, the PRT did not see this as problematic. They commended the program for the large number of courses that include a laboratory component, recognizing that laboratory work in teaching labs is student experiential learning integral to course learning outcomes.

1. While it is difficult to hear our department facilities described so negatively, we know that the PRT members are very familiar with chemistry teaching infrastructure across the province. Our faculty and staff consistently rise above the manifest limitations of our facilities, and this accounts for the many positive features of our program and the strong endorsement of current students. Nevertheless, it is clear that we could do so much more with better teaching facilities. We are fully convinced of Ryerson's commitment to achieve better facilities for Science education and are aware of the very substantial resources allocated for "bridging" research space in MaRS.

We expect to hear the provincial response to Ryerson's application for new infrastructure funding in the first quarter of 2015. If the Science building does not receive funding and/or construction within a 5 – 7 year window seems implausible, the question of renovating current space should again be actively considered.

We agree that our students (both undergraduate and graduate) would benefit from nearby additional lounge/study space. Science students have access to dedicated study/meeting space in KHE 233 with their Ryerson OneCard; this room seats approximately 30 students and currently appears to be underused. We will observe the impact of the opening of the Ryerson Student Learning Centre and its new meeting/lounge space on our students, to see if this partially or fully alleviates this student concern.

2. An additional chemistry faculty is anticipated to be the next faculty hire as part of the BMS program implementation. We see recruitment of expertise in the area of biological chemistry or biomaterials to be strategic, especially in terms of eventual growth in chemistry enrolments. Such a hire would support the development of a biological chemistry program, making efficient use of current course offerings and the multidisciplinary nature of the Department. This could set the stage for a strategy to raise entrance requirements, by providing an attractive new program that would tap into a different market segment than Chemistry currently does, without raising overall enrolments.

We agree that at least one further hire, in the area of physical or analytical chemistry, would incrementally address low numbers of current faculty in either discipline and support program improvement and research growth. It is clear that the high rates of student attrition must be addressed as part of a larger strategy for obtaining more faculty hires. However, providing adequate research and office space for new faculty hires in chemistry will remain difficult for the foreseeable future.

We agree with the PRT that more technical support is required, specifically to address the BMS program expansion. We are currently considering various staffing models (full time, part time) to meet this need and will be requesting base funding for additional technical support in the next fiscal year.

3. We agree that providing students access to chemistry-specific, career relevant software would enhance the quality of the Chemistry program. Offering molecular modeling software such as Spartan or Gaussian would be a valuable addition to the instruction currently provided in the program.

We will investigate options for improving access to computer/printing facilities for our students and faculty. It is possible that students are not well informed of the printing and computer facilities available through the Library and it might be possible to provide access to chemistry-specific software via site licenses accessible on laptop computers on loan at the Library. Given current space constraints, we do not see the merits in establishing a dedicated computing laboratory – such facilities exist in other parts of the university and there are established procedures available to students for gaining access. As desk-top computers become outdated and with ready access to wireless, another alternative would be to have a set of laptop computers loaded with chemistry software that could be available for class use or be deployed to students as needed. This strategy would require some storage space and administrative oversight, as well as a modest capital investment.

4. We agree that the average entrance grades into the Chemistry program are low and that these should be increased. Raising entrance grades without improved retention exposes the Faculty of Science to financial risk. We are exploring strategies to mitigate that risk.

The current admissions requirements for the Chemistry Program may not be serving students in the program well and could be a contributing factor to the relatively low retention rates. The PRT has suggested several modifications that are worthwhile investigating. Requiring Chemistry SCH4U for admission to Chemistry, rather than merely "strongly recommending" it is an eminently practical suggestion. Furthermore, the PRT suggests that the Grade 12U Calculus and Vectors course be "strongly recommended" if not "required" in order to assist students with their math courses (MTH 131, MTH 231, MTH 330), physical chemistry courses (CHY 381,CHY 382) and quantum physics (PCS 400) course. This is a sensible suggestion that needs to be carefully explored. We will consider options for recruiting students with higher entering averages. Since Ryerson currently offers attractive entrance scholarships for Science students, we are not sure what additional incentives might induce highly qualified high school graduates to choose Ryerson.

5. The high rates of student attrition is arguably the crucial problem that the Department must solve in the next five years, a problem shared with other science programs at Ryerson. Our Department Academic Plan will seek to balance undergraduate program enrolment with improved outcomes for students. We will seek to stabilize enrolments in all our programs so that we can reach a steady state condition by September 2016. We will raise the high school entering average for Chemistry by at least 5% over the five year period of the Academic Plan, working cooperatively with Admissions to ensure a more targeted approach to review and assessment of high school grades from applicants.

We will develop and implement a strategy for improving retention in core 2nd year courses, including initiatives such as cohort scheduling, in which laboratory sections are dedicated to particular programs rather than random arrangements of science students. Other factors that could help to improve retention would be to invest in significant resources for first and second year students, for example, improving students' math and problem-solving skills through tutorials, on-line videos, and drop-in help sessions. Additionally, the scheduling of final examinations should be such that students do not have three or more core course examinations scheduled on consecutive days; this practice almost guarantees a lack of student success.

Another strategy could be to establish a new Chemistry Program (e.g. Biological Chemistry) that would share the admission target with the current Chemistry program, making both programs more competitive, effectively raising the intake average of all chemistry students. Biological Chemistry would make effective use of the interdisciplinary nature of the Department and would be cost effective to implement, but require a lot of work to develop.

6. We agree that future hirings must be done with the objective of raising the research profile of the Department. Like many Chemistry departments in smaller universities across Canada, as a group our chemists have not fared well in NSERC Discovery funding competitions and we have seen the steady erosion of long term external funding in this area. Shoring up and advancing our institutional competitiveness for research funding is always a key goal of our faculty hiring. There is every probability that we can attract talented faculty in chemistry who will raise the research profile of the Department, although the specific research area and fit within the current faculty complement will have to be carefully considered.

While the PRT noted restricted enrolments in the fourth year undergraduate thesis course CHY 40A/B, we believe that most students who want to take the 4th year thesis course and are academically qualified have been able to do so – perhaps 1-2 students a year cannot be accommodated. Students can also gain proficiency in experimental design through Co-op placements, the integrated laboratory course (CHY 399), and summer research projects (CHY 307). The latter courses are new and were specifically designed to provide proficiency in experimental design and techniques to students who did not qualify for or who could not access the thesis course.

7. We are in agreement with the recommendation to hire another office support staff person, even though the office will need either significant renovation or additional space to house this person. We expect this to be approved in the next fiscal year, by which time BMS will be in the third year.

8. We see many benefits to hiring a laboratory coordinator for undergraduate chemistry laboratories, as is standard practice at many Ontario chemistry departments, but there are implementation challenges, particularly due to limitations imposed by our various collective agreements. Although we do not have the option of hiring a non-research faculty member – as is done at most universities with laboratory coordinators – we are developing a proposal for the creation of a laboratory coordination RFA appointment that would be structured analogously to a program directorship or associate chair position.

Conclusion:
We commend the PRT for the thoroughness of their report and their attention to detail; we are pleased that in general our program was well received and we thank them for their suggestions, which are helpful. Overall, the PRT calls for continued investment by Ryerson in the Chemistry program. We believe that past investments have been repaid many times over and played a key role in the development of the Faculty of Science and science research at Ryerson. We encourage the university to seriously consider the informed perspectives of the PRT and to provide the enhanced support that Chemistry needs to achieve its potential.

13. RESPONSE OF THE DEAN (Dr. I. Coe)

1. *Overall state of the program based on the data and analysis contained in the self-study*

The time frame of the current PPR (2005-2012) covers a time of enormous change and growth in the sciences at Ryerson, including (but not limited to the Chemistry program) and culminates in the formation of the new Faculty of Science in 2012. The Chemistry Program at Ryerson is perhaps the program with the longest history in the Faculty of Science, dating back to the establishment of Ryerson Institute of Technology. The program has evolved and changed many times since 1948, culminating in the launch of the current Chemistry program in 2005 with the core values of the program remaining true to its foundational principles of providing hands-on and applied instruction in chemistry, broadly defined. This is the first PPR for the BSc in Chemistry. The faculty and staff involved in the program are clearly deeply committed to continued growth and development of the program with improved outcomes at all levels. Overall, the program is rigorous and has a solid curricular structure. As is typical of many chemistry programs across the country, applications and enrolments tend to oscillate more extensively than for other programs (such as the life science) and outcomes/retention are well known to be challenges.

2*. Plans and recommendations proposed in the self-study report*

The self-study is an extremely comprehensive and thorough document that clearly describes the program and highlights a number of strengths, weaknesses, opportunities and threats. The Department is well aware of areas that need attention while continuing to build on established strengths. For the most part, the plans and recommendations proposed in the self-study are echoed by the reviewers, and the departmental response is appropriate.

3. *Recommendations of the PRT and response to the site visit report by Department*

3.1 Space issues need to be addressed.

The site review team did not "hold back" in their opinions regarding the quality and quantity of the current space supporting both teaching and research in Chemistry at Ryerson. Their descriptions about the space being "atrocious" and "Dickensian" are well taken and not particularly surprising to me. As I outlined in my response to the recent Biology PPR, space in support of laboratory science teaching and research at Ryerson is woefully inadequate, and since joining Ryerson in 2012, I have made "space" a top priority for the new Faculty.

There are a number of initiatives under way, to address the seriousness of the situation but none will address the fundamental lack of space nor the age and state of the current space that support Chemistry. I believe that it is a reasonable assessment that only a new Science building will truly address the team's concerns and as such, there is no easy or fast solution to resolving their concerns. However, I do not concur with the Department's response that "Ryerson has worst chemistry teaching laboratories in Ontario" -although I have no doubt that the PRT made them feel that way. Indeed, at a recent Council of Deans of Arts and Science meeting in early 2015, in conversation with a Dean of Science at another Ontario University, he confessed that they were also dealing with outdated and inadequate teaching laboratories containing wooden fume hoods (perhaps the most egregious example of outdated science labs). While hardly comforting, this does shows that the Department is not the only program in the province dealing with this challenge. As such, I was disappointed that the review team did not credit the department (faculty and staff) to the extent that I think they deserve in terms of managing to deliver programming that they are doing very effectively.

In terms of the comments about student space, the review team seemed to be unaware of the newly renovated space available for science students in KHE233 in addition to the fact that net new space to support all students has just come on-line in the form of the new Student Leaming Centre. These oversights are noted by the Departmental response and I concur.

3.2 New hires of Chemistry faculty (research) and staff (both technical and administrative) are needed, which will allow for more 4th yr advanced courses and additional research strengths.
I agree that the Chemistry faculty complement that is currently delivering the programming is spread very thin and the strain of this on the program is particularly evident when the perfect storm of multiple sabbaticals in a single year hits the department. A new hire in Chemistry is a top priority in the Faculty and will be pursued during for the 15-16 academic year, as part of the hiring plan that is currently in place. In addition, there are two industrial chairs in development, in areas that are directly relevant to chemistry and which we anticipate will add capacity and breadth to the department if successful.

Additional faculty hires will obviously support more offerings in the 4th year as well as additional research capacity (which will also provide undergraduate opportunities). Currently, the program offers a research project honours thesis course, which provides students with high quality opportunities in research labs under the guidance of engaged and supportive faculty members. In addition, undergraduate students are involved in volunteer activities within research labs. These types of more advanced laboratory experiential opportunities do not replace formal, traditional laboratory courses, but rather, provide upper level students with high quality laboratory experiences and perhaps could have been highlighted more positively by the review team. I am very well aware that many of the faculty members in chemistry have been hit particularly hard by the very intentional (and, in my opinion, short- sighted and brutal) approach of the chemistry panel at NSERC to focus research funding to the 'high- end' of the research demographic, disadvantaging, proportionally, smaller institutions, new faculty, and those with more modest (but possibly highly impactful) research endeavours. This research strategy has been the source of much dialogue across the country and within the chemistry community but appears to be leading to no change in the reviewing strategy of the Evaluation Group at NSERC (which is made up of chemistry researchers from across the country - so our peers).

In light of this, the Associate Dean, Research and Graduate Studies, has initiated a number of approaches to try and assist researchers in increasing their success with both the traditional and the non-traditional sources of funding. Grant- writing workshops and various incentives have been introduced (with a mixed response by the community). Graduate student support to those with highly rated but unfunded proposals has been provided and active promotion of alternate sources of funding, such as industry partnerships or non- Discovery Grant tri-council competitions. Changing research cultures and outcomes is a slow process and it will take some time until we see whether these strategies can help to raise overall research capacity.

In terms of technical staff replacement, strategies outlined in my response for the Biology PPR (such as more flexibility around work schedules of technical staff) are also relevant here - particularly in a climate of limited resources. However, should student retention improve, we may be able to use sensible and targeted enrolment management and subsequent revenue distributions to justify additional technical staff, ideally in support of laboratory sciences in general. This remains to be determined but will part of strategic planning going forward.

3.3 Computer/printing facilities should be created.
The review team suggests that more computer/printing facilities be created in the department for students. The Departmental response addresses this concern clearly and also notes that in the era of wireless, 24/7 connectivity, the creation of a dedicated computing laboratory for one program does not make sense (particularly with our current space crisis). I support the Department in initiatives to make students more aware of what is currently available in terms of software and hardware support, as well as in expanding the offerings of software available to students (by whatever means the program feels appropriate). These costs can be either shared (Dean + Department) immediately or we can request specific support in the annual Faculty budget depending on the amount involved.

3.4 Entrance requirements need to be raised.
The Department responds appropriately to these concerns and I concur. It is worth noting that the Faculty, as a whole, is aiming for the recruitment of more qualified and better-prepared students (not necessarily more students). The low quality of preparedness of incoming students into the sciences is a common lament, widely heard among many (but not all) science programs in Ontario and Ryerson is no exception in this regard. It is worth noting that the entering averages for students accepted into the science programs at Ryerson have been slowly climbing over the last few years (finally breaking an 80% average in 2014) and will continue to increase as we see increasing enrolment pressures. Applications to programs in science have increased by 20% since the Faculty was created in 2012.

Obviously this enrolment pressure is not equally distributed across the faculty and Chemistry in particular appears to experience fluctuations in applications of greater magnitude and unpredictability than other programs. This is not unique to Ryerson - it appears to be a characteristic of Chemistry undergraduate programs in many places. Chemistry also suffers from some worryingly low entering grades in Chemistry from some accepted students (with their other grades making up for their overall entry average). Since recruitment of better qualified and prepared students is a Faculty priority in our academic plan, the Dr. Marcus Santos, (Associate Dean, Undergraduate Science Programs and Student Affairs), in conjunction with Dr. Andrew McWilliams, (Chemistry Co-op Faculty Advisor; Academic Coordinator First Year and Common Science Office) have been looking in detail at the demographics of our incoming students, with the assistance of the Admissions and Recruitment Office. These analyses are on-going and the ultimate aim to refine the incoming requirements for all programs (e.g. establish a minimum cut-off for the science/math requirements and then take the average for the best 6 12U courses) as well as identify markers or profiles that might put students at risk during their first year. Other recommendations including requiring (rather than "recommending") specific 12U courses will have to be considered and the feasibility and consequences of making changes to the current requirements will have to be modelled. The Department is well aware of these issues and is best positioned to make recommendations about any changes in incoming requirements.

3.5 Additional course choices at the upper level should be made available.
Net new faculty in Chemistry will help with the development of additional courses (see 3.2). Another option that was recently raised by the Chair of the Department was the possibility of coordinated teaching with chemistry faculty at other institutions. I encourage creative solutions of this sort, which use

technology to overcome both distances, possibly small class sizes at each location and which promote interactions beyond the bounds of the immediate program/department. The feasibility of this is not clear but it something that is worth further discussion and I am willing to assist the program as requested.

3.6 Retention needs to be improved.
This has been a major issue and a serious problem for the program and continues to be a priority area where we seek improvement as a Faculty. The Departmental response is substantive and well-reasoned and does not need to be duplicated here beyond my endorsement of much that is proposed. I will add that there a number of other initiatives that are in development, that I believe will significant improve retention that are not mentioned, these include new programming and initiatives to optimize and promote faculty:student interactions and broaden opportunities for students to engage in a variety of activities related to their current and future goals. These initiatives include (but are not limited to) the mentoring and professional skills program known as RySciMatch, led by Chemistry professor, Dr. Bryan Koivisto, the formation of a Ryerson Science Students society - which is bringing the various course unions together and which is supported by and well connected to the Dean's office, the Women in Science @Ryerson (WISR) initiative which is aimed at providing a community for students, faculty, staff and others interested in the promotion, retention, recruitment and advancement of women in science. In addition, there is a rapidly developing Science Innovation Zone that will provide zone- learning activities, specifically in an experimental science hub under Dr. Koivisto's guidance. We have also noted a significant up-tick in enrolment in co-op programming, which we believe is a consequence of the presence of an "embedded" career counselor, Rebecca Dirnfeld, within the Faculty who has been providing targeted guidance and advice to science students at the local (and much more accessible) level.

One proposal by the department that may be less feasible is the suggestion for a new undergraduate program in Biological Chemistry. Not only is this is huge amount of work, it seems unlikely to be feasible at this time, given that it was not included in the Strategic Mandate Agreement signed with the Province and thus would not receive approval at Quality Council. The possibility of a specialization or stream could be investigated although whether this would constitute a "major change" (and thus be subject to extensive review and possible rejection) or not, would need to be clarified. Either way, it is clear that there is little appetite at this time for universities to bring forward new programming that has not been agreed to as part of the SMA process therefore focusing on other creative and impactful routes to improving retention, as we are doing and planning, appears to be the most likely solution to raising retention (and attracting better qualified students).

3.7 Research capacity needs to be increased.
See 3.2

3.8 Hire a Laboratory Coordinator for undergraduate chemistry laboratories.
This is an excellent idea that correlates with the approach at many other institutions where there are experts, sometimes with advanced degrees in laboratory sciences or specific expertise and passion for innovation in pedagogy, whose primary role is to support, guide and advance the students experiences in the laboratory sections of undergraduate programming. At other institutions, these individuals may be staff members (possibly the equivalent of MAC at Ryerson) or they can be teaching stream (also known as Alternate Stream) faculty members. The Department recognizes the value of this approach and also highlights the constraints. It is deeply unfortunate that innovation and advancement of pedagogy in the sciences, which is rapidly being embraced as a valid field of research and engagement globally, and among some of our comparator and neighbouring institutions, cannot be readily or easily adopted because of these constraints. I will work with the Department and the program to find creative solutions that address this issue.

Curricular innovation and development continues to be discussed institutionally and, no doubt, new and different approaches may be proposed and adopted. The Faculty of Science is committed to producing well-rounded global citizens who possess a solid and rigorous foundational knowledge in science with an understanding of the way that science permeates every aspect of life and the recognition of the natural and power synergies between the sciences and the arts and humanities.

14. ASC EVALUATION
The Academic Standards Committee assessment of the Periodic Program Review for Chemistry (Bachelor of Science) indicated that the review provided a well-written, candid evaluation of the program. The ASC also noted the program's commitment to quality student intake and quality graduates.

The Academic Standards Committee recommends that the program provide a follow-up report on the status of the initiatives outlined in the Developmental Plan. The follow-up should also include an update on (1) the mapping of core concepts and skills, (2) the analysis of entrance requirements, (3) the registration by cohort pilot project, (4) the co-operative education option revised model and (5) the renewal of laboratory experiments.

Follow-up Report
In keeping with usual practice, the follow-up report which addresses the recommendation stated in the ASC Evaluation Section is to be submitted to the Dean of Science, the Provost and Vice President Academic, and the Vice Provost Academic by the end of June, 2016.

15. IMPLEMENTATION PLAN
i. Approval of the recommendations set out in the Final Assessment Report:
The recommendations have been approved by the Dean and by Senate. Ryerson University's IQAP Policy 126 states: "Senate is charged with final academic approval of the Program Review."

ii. Responsibility for providing any resources made necessary by those recommendations:
Ryerson University's IQAP Policy 126 states: "The Chair/Director and Dean are responsible for requesting any additional resources identified in the report through the annual academic planning process. The relevant Dean(s) is responsible for providing identified resources, and Provost is responsible for final approval of requests for extraordinary funding. Requests should normally be addressed, with a decision to either fund or not fund, within 2 budget years of the Senate approval. The follow-up report to Senate will include an indication of the resources that have been provided."

iii. Responsibility for acting on those recommendations:
Ryerson University's IQAP Policy 126 states: "If the report includes a recommendation for approval of the program review, it will include a date for a required follow-up report to be submitted to the Dean and Provost on the progress of the developmental plan and any recommendations or conditions attached to the approval."

iv. Timelines for acting on and monitoring the implementation of those recommendations:
Ryerson University's IQAP Policy 126 states: "The initial follow-up report is normally due by June 30 of the academic year following Senate's resolution. The Provost may require additional follow-up reports."

16. REPORTING
i. The distribution of the Final Assessment Report (excluding all confidential information) and the associated Implementation Plan to the program, Senate and the Quality Council:
The Office of the Vice Provost Academic is responsible for distribution of the Final Assessment Report to all relevant parties.

ii. The institutional Executive Summary and the associated Implementation Plan be posted on the

institution’s website and copies provided to both the Quality Council and the institution’s governing body:
The Office of the Vice Provost Academic is responsible for posting the information on the Curriculum Quality Assurance website at www.ryerson.ca/curriculumquality. The information is provided to the Board of Governors on an annual basis.

iii. The timely monitoring of the implementation of the recommendations, and the appropriate distribution, including web postings, of the scheduled monitoring reports:
The Office of the Vice Provost Academic is responsible for following up with the programs and their respective Deans to ensure the recommendations are implemented. The follow-up report is submitted to the relevant Dean(s) and the Vice Provost Academic for review.

iv. The extent of public access to the information made available to the public for the self-study:
Ryerson University’s Senate Policies are available to the public through the Senate website at www.ryerson.ca/senate. This includes Policy 110 Institutional Quality Assurance Process and Policy 126 Periodic Program Review of Graduate and Undergraduate Programs. The Final Assessment Report (excluding all confidential information) and the associated Implementation Plan is available on the Curriculum Quality Assurance website at www.ryerson.ca/curriculumquality. A summary of the Report of the Review Committee is contained within the Final Assessment Report.
A summary of the responses provided by the Dean and the program to the Report of the Review Committee is contained within the Final Assessment Report.

17. SCHEDULE
The next periodic program review for the Bachelor of Science in Chemistry is scheduled for 2022 – 2023.