

FINAL ASSESSMENT REPORT

**PERIODIC PROGRAM REVIEW (PPR)
Bachelor of Engineering
In Biomedical Engineering
Faculty of Engineering and Architectural Science**

In accordance with the Institutional Quality Assurance Process (IQAP), this final assessment report provides a synthesis of the external evaluation and the internal response and assessments of the undergraduate **Biomedical Engineering** program. The report identifies the significant strengths of the program, together with opportunities for program improvement and enhancement, and it sets out and prioritizes the recommendations that have been selected for implementation.

The Implementation Plan identifies who will be responsible for leading the implementation of the recommendations; who will be responsible for providing any resources entailed by those recommendations; and timelines for acting on and monitoring the implementation of the recommendations.

SUMMARY OF THE PERIODIC PROGRAM REVIEW OF THE BIOMEDICAL ENGINEERING PROGRAM

The Biomedical Engineering (BME) program submitted a self-study report to the Vice-Provost Academic on January 28, 2019. The self-study presented the program description and learning outcomes, an analytical assessment of the program, and program data including the data collected from a student survey along with the standard University Planning data tables. Appended were the course outlines for all core required and elective courses in the program and the CVs for all RFA faculty members in the Department of BME and other faculty who have recently taught core courses (required and/or elective).

One arm's-length external reviewer, Dr. Bob Dony, School of Engineering at the University of Guelph, and one internal reviewer, Dr. Michael Kolios, Department of Physics at Ryerson University, were appointed by the Dean of the Faculty of Engineering and Architectural Science from a set of proposed reviewers. They reviewed the self-study documentation and then conducted a site visit at Ryerson University on May 23 and 24, 2019.

The visit included meetings with the Provost and Vice-President Academic; Vice-Provost Academic; Dean, Faculty of Engineering and Architectural Science; Chair, Electrical, Computer and Biomedical Engineering; and the BME Program Director. The Peer Review Team (PRT) also met with several members of the BME program within the Department of Electrical, Computer and Biomedical Engineering, including staff, students, and faculty members. A general tour of the campus was provided, including a tour of the program facilities, labs, classrooms, and the library.

In their report, dated May 23-34, 2019, the PRT provided feedback that describes how the BME program meets the IQAP evaluation criteria and is consistent with the University's mission and academic priorities. The PRT also noted the pride exhibited by all those involved in the BME program, particularly as the first stand-alone biomedical engineering program in Canada to have received accreditation by the Canadian Engineering Accreditation Board (CEAB).

The main areas of strength identified by the PRT include:

- An innovative program that was the first accredited stand-alone biomedical engineering program in

Canada.

- Strong curriculum with a focus in the fields of devices and software, and signals and systems, building on the existing expertise of the ECBE department.
- Excellent student population as the program attracts high achieving students.
- Student population at gender parity, an achievement unique across all engineering programs at Ryerson by a wide margin.
- Excellent calibre of faculty, with a high proportion of female faculty dedicated to the BME program.
- Excellent opportunities for experiential learning through labs, projects, and the Biomedical Zone.

The PRT also identified areas for improvement. The most significant recommendations for enhancing the undergraduate program include an increased effort on student internships specifically focused for biomedical engineering, and a broader BME curriculum to include more in-depth coverage of areas such as biomechanics and tissue engineering.

The Chair of the Electrical, Computer, and Biomedical Engineering program submitted a response to the PRT Report on November 18, 2019. The response to both the PRT Report and the Program's Response was submitted to the Vice-Provost Academic by the Dean of the Faculty of Engineering and Architectural Science on November 5, 2020.

The Academic Standards Committee completed its assessment of the Chemical Engineering Program Review on December 10, 2020. The Committee indicated that a thorough, analytical and self-critical program review was conducted. The School integrated into the developmental plan feedback from students, alumni, employers and peer reviewers, and outlined a comprehensive plan for program enhancements moving forward.

The Academic Standards Committee recommends that the program continue, as well as provide a one-year follow-up report by June 30, 2022, as follows:

1. Update on the status of the initiatives outlined in the Implementation Plan

Presented to Senate for Approval: January 26, 2021

Start date of next Periodic Program Review: 2023-24

SUMMARY OF THE REVIEWERS' RECOMMENDATIONS WITH THE PROGRAM'S AND DEAN'S RESPONSES

RECOMMENDATION 1. Explore further opportunities within existing courses to integrate the regulatory aspects of the Professionalism LO within the context of the more technical material as this is of particular importance to the biomedical engineering field.

Department's Response: Currently the Professionalism LO (as defined by the corresponding CEAB GA) is being assessed in representative courses in the early, middle, and graduating courses. Five of the higher year courses (i.e. 7th and 8th semester courses) cover this LO and 4 out of these 5 courses are technically specialized courses including EDP. In addressing the specific comment on including regulatory aspects of professionalism in the context of technical material, this is currently covered to certain degree in design intensive courses such as EDP (BME700/800 via Faculty Lab Coordinators) and BME674. In the near future, we will expand this and include relevant regulatory aspects in higher year courses (7th and 8th semester) covering engineering design, safety aspects, therapy, bioethics, and applications to health care.

Dean's Response: In 2017, FEAS developed an overarching philosophy, the All-In Approach to Education, that recognizes how a student's success depends on their academic, personal, community and professional

experiences at Ryerson University and beyond. The All-In Approach is a framework that guides our improvements in both the curricular and co-curricular realm.

At present, regulatory aspects of professionalism are covered in design intensive courses such as Engineering Design Projects (EDP) (BME 700/800) and BME 674. In the near future, we will be including the relevant regulatory aspects of engineering design, safety aspects, therapy, bioethics, and applications to health care in upper year courses (7th and 8th semesters). In line with the Faculty's All-In Approach to Education and in compliance with the graduate attributes set out by the Canadian Engineering Accreditation Board, the biomedical engineering program maintains a strong focus on both technical and durable skill development.

RECOMMENDATION 2. While Biology (SBI4U) could be considered as one of the admission requirements given the nature of the program, the students still do very well in this part of the curriculum. Further, this requirement would potentially limit the pool of eligible applicants as it would be the only engineering program with such a requirement. If in the future biomedical engineering students have difficulties with the topic, it could added as an admission requirement.

Department's Response: We appreciate the suggestion of the reviewers. Currently the BME students (without SBI4U) are provided with ample exposure to biology over 3 courses in the curriculum to the extent needed for a Biomedical Engineering student. Based on the student performance in these courses and their comfort level in integrating and applying this knowledge in the higher year technical courses that demand this background, we do not foresee the lack of SBI4U having any negative impact. It is further noting that the admission averages are amongst the highest in engineering, thus attracting outstanding students.

Dean's Response: The PRT's recommendation to consider including Biology (SBI4U) as an admission requirement has been taken under consideration. It is important to note that current BME students are provided with ample exposure to biology over three courses (BLG 143, BLG 601, and BLG 701) offered in the curriculum. Based on recorded student performance in these courses and students' demonstration of comfort integrating and applying their knowledge in the upper year technical courses, we are not considering changing the admission requirements at this time.

RECOMMENDATION 3. Both students and faculty have expressed interest in having more advanced courses in areas such as biomechanics and tissue engineering. The addition of such courses would alleviate the perception expressed by some that the program has too narrow of a focus in electrical and computer engineering.

Department's Response: Currently the BME UG curriculum does include Biomechanics (BME406) and Tissue Engineering (BME703). BME is highly interdisciplinary with a larger span of specialized areas compared to traditional engineering programs. While it may be desirable to cover this large span as much as possible, considering it is a 4-year program (i.e. unlike 5 year BME programs) and to avoid venturing into too narrow specialization that will defeat the "systems approach" of the current program, it would be more appropriate that we allow the our graduate BME program to cover such advanced versions of courses in these areas.

Dean's Response: The current biomedical engineering program includes Biomechanics (BME 406) and Tissue Engineering (BME 703). Furthermore, BME 674 covers instrumentation for medical devices and the department has plans to develop new courses on devices and the regulatory aspects related to medical device development. Biomedical engineering is a 4-year program and highly interdisciplinary. Given these differentiating factors, the program has avoided narrow specializations in the undergraduate program in favor of achieving a systems approach that better prepares prospective graduate students to choose advanced courses that support their own decisions to specialize in the areas of their choice.

RECOMMENDATION 4. The faculty did express concern that the current departmental structure may not be conducive to hiring additional faculty with expertise in biomechanics or tissue engineering.

Department's Response: One of the BME strategic hires is a well-known tissue engineering expert while we leverage the expertise available in the Mechanical Engineering for Biomechanics. All BME hires in the recent past

had BME representation in the hiring committee and ALL BME faculty members were consulted during each of the BME hiring. In fact, right from deciding on the expertise requirements and position description until the hiring is complete, ALL BME faculty members have been closely consulted.

Dean's Response: n/a

RECOMMENDATION 5. The department initially created the BME program with minimal additional resource requirements, drawing on the existing expertise and infrastructure within the department. While additional resources have been added with faculty hires and new laboratory equipment, the growth in the program is placing strains on the current abilities of the department to deliver the program. Although the department continues to deliver an excellent program that attracts top students, the reviewers feel that the current situation is not sustainable. With a minimal faculty complement, the program is vulnerable to both scheduled and unscheduled faculty member leaves. Because of the number of recent hires, the faculty is relatively young. As a result, the program has not yet had to deal with the full regular cycle of sabbatical leaves. This is a concern. As well, the younger faculty profile most likely means a higher than average number of parental leaves in the near future. Again, with an already minimal faculty complement, such leaves could significantly affect the department's ability to deliver the program.

Department's Response: The program is in its 11th year, we currently have more BME specific faculty members than we originally started. Hence, in relative terms we are in much better situation in terms of number of faculty members (with another new addition next year). We expect the situation to only continue to improve with accumulation of experience by faculty members. While we do need new additional faculty members specific to BME for stability and expansion, being housed in the largest departments of the University, and having run this program for 11 years with lesser resources than the current situation, we do not foresee that we will be unable to deliver the program.

Dean's Response: We have been extremely impressed with the caliber of talent that the biomedical engineering program has attracted. Over the last three academic years, the number of faculty members in the biomedical engineering program has a net increase of three. Already the three new hires have been committed to specialized courses and/or developing new specialized courses. Our dedicated biomedical engineering faculty members represent a diversity of research interests and expertise. Their dedicated teaching, research and service are further enhanced by the fact that FEAS is home to over 25 interdisciplinary faculty members who conduct research in the expansive field of biomedical engineering.

RECOMMENDATION 6. One of the features of an accredited engineering program is the culmination with a capstone engineering design project (EDP) course. Such a course requires a significant amount of supervision by the faculty advisor assigned for each design group. With a low faculty complement, some faculty end up taking on a large number of EDP groups. The students mentioned a case where a single faculty member had been advising 8 student groups. Others mentioned they could not find suitable projects. The quality of advising can only suffer in such instances. The low number of faculty also means that the graduate student pool from which to draw teaching assistants for undergraduate courses is limited. Again, given the specialized nature of many courses in the program, it can be a challenge finding qualified people from this limited pool.

The capstone EDP experience could be enhanced in several ways. With an increased faculty contingent, the quality of advising would be improved as the number of groups per faculty would decrease. Further, there is an opportunity for improving the integration with hospital-based projects through iBEST. While the structure currently exists, closer collaboration with the engineering faculty and hospital physicians would significantly enhance the opportunities for student projects.

Department's Response: Specific to EDP groups, in BME, each EDP group consist of a maximum of 3 students (i.e. unlike typical 6 or 7 students in other programs). So 8 groups consist of a total of 24 students, which is a fairly small and optimal group of students (amounting to approx. a typical "section" at Ryerson) for a faculty member

to supervise. At dept. of ECBE, we follow the principle of assigning designated faculty members (with a P.Eng. licence) with significant experience and expertise to EDP to deliver quality learning experience for students. Unlike, allowing every faculty member to supervise 1 or 2 groups, our approach is geared towards highly trained and experienced faculty members to handle EDP. With decades of positive acknowledgements and appreciations received for the way the dept. of ECBE runs the EDP course, we believe our approach of using fewer trained and experienced faculty members to supervise more groups is effective in delivering quality learning experience.

Regarding the unavailability of suitable topics, of course this is a common complaint, however, considering the vastness of BME discipline it would be unrealistic to cover all the areas. Most importantly, our philosophy is not to put the focus on what the project is, but to emphasize and train the students in design process and project management irrespective of the topic. The topic is only a vehicle to make the student journey through the design process and project management.

Regarding low number of faculty members, we are in the process of expanding with 3 new hires in the recent past specifically for BME with one more addition next year. Already the 3 new hires have been committed to specialized courses and/or developing new specialized courses. We do need additional new faculty members for stability and expansion of the curriculum.

Regarding hospital collaboration for EDP, this is currently being done through both iBEST initiated Clinician participation and through individual EDP faculty member's hospital research collaborations.

Dean's Response: The PRT made mention of a low number of faculty members dedicated to the Engineering Design Projects (EDP)/Capstone Projects. The EDPs are carried out in groups consisting of a maximum of three students. A faculty member supervises eight groups consisting of a total of 24 students, which amounts to approximately a typical "laboratory section" at Ryerson. ECBE adheres to a principle of assigning designated faculty members with a P.Eng. license with significant experience and expertise in engineering design projects to deliver quality learning experiences for students. ECBE's approach is geared towards highly trained and experienced faculty members to handle EDP. Thus far, the Department has received positive acknowledgements from students and faculty alike and is confident with its decision to focus on fewer highly trained faculty members to effectively deliver a focused quality learning experience.

The Department acknowledges that there will always be a student demand for more topics than are provided. This is a common complaint. The Department's philosophy involves using an EDP topic as the vehicle to support students learning journeys through the design process and project management. ECBE emphasizes training students in the design process and project management skills irrespective of specific topics and as such are confident in the learning outcomes of their approach. With the addition of new faculty member in the biomedical engineering program, it is expected that more topics would be available for biomedical engineering students.

RECOMMENDATION 7. The BME program, like other engineering programs at Ryerson, has an internship option for students. A single staff member supports the three programs within the department. Not only is this a concern for the additional workload of the BME program, but the nature of the positions makes this a bigger concern. As a University and Faculty the prides itself on providing the best experiential learning opportunities, we consider the lack of dedicated resources to finding internship opportunities in what the City of Toronto has designated as the "Discovery District", home to seven world-renowned hospitals and more than thirty specialized medical and related sciences centres, a missed opportunity.

Department's Response: We agree with the reviewers; we definitely need additional staff members (as also noted by CEAB visitors) for BME and resources to improve our outreach in obtaining internship opportunities for students.

Dean's Response: In late 2017, FEAS launched a central office to manage optional co-operative internship programs (CIP) for all of the engineering programs except Chemical Engineering which has a mandatory co-operative program. Since this time, the team has grown from 1 staff member to 5. This team collaborates with existing embedded staff within departments (including ECBE) to support all aspects of CIP including new on-line platforms (Salesforce and Orbis) for efficient student and employer engagement related to applications, job

postings, etc; student and employer recruitment events and workshops; administration and evaluation of the placement experiences; and delivery of soft skill development modules associated with career readiness and professional networking. In Fall 2019, the FEAS CIP office rolled out the first centralized student enrolment in FEAS CIP.

The FEAS CIP office is continuing to work on improving the co-op placement rate of BME and other engineering students through the following activities: 1) identifying and working closely with students who are less engaged (i.e. do not apply to posted jobs, apply but do not secure interviews and/or job offers), 2) continuing to work with existing employers and promote jobs that are more relevant to specific engineering disciplines, 3) developing more partnerships with new employers/industries interested in specific engineering disciplines, aiming towards a 3 job postings to 1 student ratio, and 4) planning employer engagement events/opportunities that target specific engineering discipline students. We are reaching first and second year students to promote CIP earlier so that they are better prepared to meet the expectations set by the program and employers.

RECOMMENDATION 8: Both students and faculty have identified a lack of identity of the program within the department. While the recent name change does acknowledge the new BME program within the department, there is still the feeling that the other two programs are the primary focus of the department. This sentiment was particularly strong from the students we interviewed.

Department's Response: We agree with the reviewers; however, we have already started moving in the right direction with the name change. In addition, with the recent new hires specific for BME and plans for increasing BME student interactive events is expected to change the sentiment over time. (Example interactions will include, town hall style meetings, pizza lunch with faculty members, hospital visits, iBEST activities etc.)

Dean's Response: Ryerson University Senate unanimously approved the name change of the Department in May 2018, at which point the Department of Electrical and Computer Engineering changed its name, all branding and marketing materials to the Department of Electrical, Computer and Biomedical Engineering. Since that time, there has been a focused and intentional effort to ensure biomedical engineering students feel welcomed and engaged within their department and the wider faculty.

In line with our All-In Approach to Education, we are working diligently to significantly improve the student experience through five co-curricular hubs—Well-being, Academic Success, Leadership, Career Development and Experiential Learning. We provide a multitude of resources and opportunities within these hubs to help students grow into imaginative and exceptional leaders. For example, in light of the COVID 19 pandemic, FEAS launched a new Peer Networking Program that involves 47 paid student staff positions to serve in various peer advisor capacities to support all FEAS students by answering their questions, providing support and facilitating skill building workshops. BME students constitute the largest ratio of these paid student positions.

The student experience and available co-curricular opportunities are one of the program's greatest strengths. For example, BME students have access to join over 15 student design teams, student government opportunities through Ryerson Engineering Student Society (RESS), as well as countless student groups like the Biomedical Engineering Society (BMES), IEEE Engineering in Medicine & Biology Society - Ryerson Chapter, Engineers Without Borders (EWB), EngOUT, Institute of Healthcare Improvement, and National Society of Black Engineers (NSBE). BME students are also heavily engaged in Ryerson's Zone Learning ecosystem and have been some of the most successful recipients of the Esch Engineering Innovation and Entrepreneurship Awards.

While FEAS believes strongly in the benefits of a more centralized suite of offerings for students to ensure greater interdisciplinarity and to increase peer networking across programs, the Department of ECBE also offers biomedical engineering student specific events in the form of orientations, pizza parties, co-operative internship recruitment events and special lectures and workshops from the biomedical engineering industry. These examples will continue to increase and improve in quality as they coincide with a commitment to increase alumni and employer engagement in ways that improve the student experience.

RECOMMENDATION 9: Given the extra complexity of the regulatory requirements within the biomedical

engineering field, there appears to be a lack of integration of regulatory issues within the technical subjects within the curriculum.

Department's Response: In addressing the specific comment on including regulatory aspects of professionalism in the context of technical material, this is currently covered to certain degree in design intensive courses such as EDP (BME700/800 via Faculty Lab Coordinators) and BME674. In the near future, we will expand this and include relevant regulatory aspects in higher year courses (7th and 8th semester) covering engineering design, safety aspects, therapy, bioethics, and applications to health care.

Dean's Response: n/a

RECOMMENDATION 10: While there is an advisory committee at the department level, a specific advisory committee for the program that includes representation from the surrounding hospitals and BME related companies would provide a more focussed forum on program issues.

Department's Response: The BME program does have an advisory committee including representation from hospital and external members.

Dean's Response: n/a

ADDITIONAL PROGRAM RECOMMENDATIONS IN SELF STUDY

1. Increase the number of 4th year professional electives available to students.
2. Improve TA support to undergraduate courses with overall increased stringency on the requirements for selection and also with adequate training and preparation.
3. Integrate opportunities for students to improve and build on soft skills (e.g., leadership, oral presentation, professionalism)
4. Increase the number of co-op internship jobs available to students in BME

IMPLEMENTATION PLAN

Priority Recommendation #1: <i>Increase the number of 4th year professional electives available to students</i>
Rationale: <i>There is an urgent need to introduce more technical electives in the 7th and 8th semester to give students more choice. Elective courses in specialized areas of bio-robotics, advanced medical instrumentation, etc. would be valuable additions.</i>
Implementation Actions: <ul style="list-style-type: none"> • <i>Identify advanced topics that are lacking in the curriculum;</i> • <i>Design courses around the advanced topics identified above</i>
<ul style="list-style-type: none"> • Timeline: <i>(2018/19: identify topics that can be introduced through new 4th year professional electives</i> <p><i>2018-2020: design and integrate into curriculum 4 courses over 2 years</i></p>
Responsibility for
a) leading initiative: <i>Department Chair, Program Director, Curriculum Committee, Stream</i>
b) approving recommendation, providing resources, and overall monitoring: <i>Curriculum Committee, Stream</i>

Priority Recommendation #2: <i>Improve TA support to undergraduate courses with overall increased stringency on the requirements for selection and also with adequate training and preparation</i>
Rationale: <i>Notwithstanding our efforts to select appropriate graduate students as teaching assistants in our labs, our recent surveys have indicated that there are courses where the TAs are not well prepared to assist students.</i>
Implementation Actions: <ul style="list-style-type: none"> • <i>identify key courses that have a large number of TAs;</i> • <i>increase preparation/training hours for TAs in those courses;</i>

- require TAs to perform and complete all labs that undergraduate students will be doing;
- introduce and hire Lab Leads to roam labs and provide extra support and supervision.

Timeline: 2020-21 academic year

Responsibility for

a) leading initiative: *Department Chair*

b) approving recommendation, providing resources, and overall monitoring: *Department Chair, Dean*

Priority Recommendation #3: *Integrate opportunities for students to improve and build on soft skills (e.g., leadership, oral presentation, professionalism)*

Rationale: *Our student survey identified skill areas that are not well addressed. Soft skills are not formally part of the engineering curriculum but they are essential skills for a professional engineering in industry.*

Implementation Actions:

- *identify key core courses where students can present orally*
- *provide leadership opportunities to senior graduate students by creating a program that will allow them to mentor students in early years*
- *work with career centre to have them visit classes and hold seminars to relay to students the aspects of professionalism that are essential and to help them cultivate them*

Timeline: 2020-21 academic year

Responsibility for

a) leading initiative: *Department Chair, Program Director, Stream*

b) approving recommendation, providing resources, and overall monitoring: *Department Chair, Dean*

Priority Recommendation #4: *Increase the number of co-op internship jobs available to students in BME*

Rationale: *Our internship program is proving to be very popular. In 2018/19 we will be having 80 students on internship, which is a record. Unfortunately, only 4 of these positions were in Biomedical Engineering.*

Implementation Actions:

- *Identify potential employers in GTA and Southern Ontario*
- *Create 1-page prospectus/flyer that provides quick info on our co-op internship and benefits to the employer*
- *Plan site-visits with potential employers to discuss their participation*

Timeline: 2020-25 academic year

Responsibility for

a) leading initiative: *Department Chair, FEAS*

b) approving recommendation, providing resources, and overall monitoring: *Department Chair, Dean*