Physics for Modern Technology Program Review Self-Study Report

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List of Acronyms

AAPT: American Association of Physics Teachers

APEGBC: Association of Professional Engineers and Geoscientists of British Columbia

BCAPT: British Columbia Association of Physics Teachers

BCIT: British Columbia Institute of Technology

BEng: Bachelor of Engineering

BSc: Bachelor of Science

CAP: Canadian Association of Physicists

CASCA: Canadian Astronomical Society

CCD: Charge-Coupled Device

CLO: Course Learning Outcome

CMOS: Complementary Metal-Oxide Semiconductor

EPT: Environmental Protection Technology

FSH: Faculty of Science and Horticulture

FTE: Full-time Equivalent

GPA: Grade Point Average

ISA: International Society of Automation

JPEC: Junior Physics and Engineering Challenge

KPU: Kwantlen Polytechnic University

KSC: Kwantlen Science Challenge

LIDAR: Light Detection and Ranging

MSc: Master of Science

OEM: Original Equipment Manufacturer

OER: Open Educational Resource

PAC: Program Advisory Committee

PCB: Printed Circuit Board

PhD: Doctor of Philosophy

PLO: Program Learning Outcome

PMT: Physics for Modern Technology

P.Phys.: Professional Physicist

RF: Radio Frequency

SEM: Scanning Electron Microscope

SFU: Simon Fraser University

TRU: Thompson Rivers University

UBC: University of British Columbia

UNBC: University of Northern British Columbia

VCC: Vancouver Community College

Memo from Dean/Associate Dean

KPU | KWANTLEN POLYTECHNIC UNIVERSITY
Faculty of Science and Horticulture

Where thought meets action

May 25, 2022

Dean's response memo: Program review for Physics for Modern Technology (PMT)

To whom it may concern,

It is my pleasure to provide a response to the Physics for Modern Technology (PMT) Program Review Self-Study Report (SSR), dated May, 2022.

This SSR represents a substantial body of work that encompasses not only the explicit requirements of the program review process as mandated by BC's Ministry of Advanced Education, Skills and Training (MAEST) but also the spirit of continuous quality improvement that forms the foundation of the process. The PMT program review committee has examined the past, present and future of PMT through a lens of appreciative inquiry and rigorous self-appraisal.

The report articulates many of the program's unequivocal successes. These include relevance to industry, job preparedness, student satisfaction and teaching excellence. In addition, the PMT program exemplifies KPU's polytechnic mandate, with its synthesis of experiential learning in the classroom and laboratory and a clear line of sight to industry and job-preparedness.

I am in agreement with the conclusions and recommendations that are described in chapter six of the report. The recommended curricular changes surrounding biology, computing and mathematics content are evidence-based and forward-focused and demonstrate a collective willingness in the department to make substantive changes where necessary. In addition, it is commendable that the report is explicit about the need to discontinue a proportionate amount of content in the program so that the curriculum does not become supersaturated and unduly onerous for students. Programs often recognize the need for new and more current content, but more rarely have the courage to stop doing some things in order to start doing others.

Two other recommendations of note include efforts to increase student recruitment and retention

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and increase the frequency and depth of connection with the program advisory committee (PAC).

The SSR is justifiable candid about the challenges with recruiting and retaining students in the program, pointing to the small proportion of junior level students who progress to senior level courses. While identifying the need for faculty-wide initiatives, there is also an expression of ownership of the communication and marketing of the program. The report rightfully describes many of the actions that the physics faculty members can take to ensure that this compelling program becomes more visible in the communities that KPU serves.

The report also highlights the need for increased engagement and frequency of meetings with the PAC. These have taken place infrequently, and I would encourage the program to work toward a cycle of meeting twice per year.

In sum, I am supportive of the SSR and its conclusions and recommendations. The SSR team members are to be commended for crafting a thoughtful and critical examination of their program identity and practices.

Respectfully submitted,

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1. Introduction

1.1. Overview of the Program(s)

Program Under Review

The Bachelor of Science, Major in Physics for Modern Technology (PMT) is an undergraduate program offered by the Department of Physics, Astronomy and Engineering at Kwantlen Polytechnic University (KPU). Most industrial achievements are based on science, and although physicists play an important role in technology development, there is a dearth of programs in North America designed to prepare physics graduates for work in industry. The major goal of the PMT program is that graduates will find employment in local high-tech industry upon graduation. It is specifically designed to address the long-standing issue with many traditional science degrees in which graduates are not prepared to apply their knowledge and skills in the workplace after graduation. PMT is the first physics degree in Canada with this explicit goal.

In 2010, the Department initiated the idea of a program to specifically tackle this issue. This was followed by a visit to similar successful applied physics programs offered in Ireland at Galway-Mayo Institute of Technology, Cork Institute of Technology, & Waterford Institute of Technology in 2011. At the same time, consultation with local high-tech companies revealed the demand for an applied physics program. In 2012, KPU approved the PMT program, followed by approval from the of BC Ministry of Advanced Education in 2013.

The PMT program underwent a "soft launch" in 2014 when a selection of new courses were offered for the first time. The Program Advisory Committee (PAC) was established within the same year. In 2015, the PMT program fully launched, which resulted in the first students graduating in 2018. PMT graduates have proven to be successful in securing technical, scientific, and management roles in the local tech sector.

Admission Requirements

Admission to the PMT program is classified as open-intake – there is no set limit to the number of students admitted. For students intending to pursue the PMT program directly from high-school or without any post-secondary experience, admission into the program is a two-step process. First, these students must be admitted to the Faculty of Science & Horticulture (FSH), which requires meeting KPU's undergraduate English proficiency requirement. These students are classified as undeclared-FSH students with a Physics intention. In order to complete the required first-year courses in the PMT program, students must meet the following prerequisites:

- Math 12 (C+)
- Physics 12 (P)
- Chemistry 12 (C+)
- English 12 (B)

Students missing any of the above prerequisites can upgrade at KPU.

The second step to enter the PMT program is program declaration. At the time of declaration, the student must satisfy all of the following requirements:

- In good academic standing with the University
- Completion of a minimum of 24 credits of undergraduate coursework, including the following:
- 3 credits of ENGL at the 1100 level or higher

- PHYS 1102 or PHYS 1220, with a minimum grade of “C”
- MATH 1220 or MATH 1230, with a minimum grade of “C”

All KPU students intending to graduate with a bachelor’s degree from the Faculty of Science and Horticulture degree must declare their major by the time they complete 60 credits of undergraduate coursework.

Other Pathways into the Program:

Students with post-secondary experience at KPU or any other post-secondary institution can declare directly into the PMT program if all the declaration requirements are met. In particular, students who have successfully completed KPU’s Certificate in Engineering meet the PMT declaration requirements and may transfer directly into the second year of the PMT program. Note, Engineering Certificate graduates would still need to complete BIOL 1110 as a graduation requirement. Students transferring from other KPU programs or post-secondary institutions will be required to complete PHYS 1600 Introduction to Modern Technology as a prerequisite for some second-year PMT courses.

Credential & Curricular Requirements

Currently, students must meet the following minimum requirements to graduate with a Bachelor of Science from the Faculty of Science and Horticulture:

- 120 credits from courses at the 1100 level or higher.
- 45 credits from a minimum of 15 courses at the 3000 level or higher, including 9 credits at the 4000 level.
- 18 credits of breadth electives (see Electives below) including:
    - at least 12 credits from courses that are offered outside the Faculty of Science & Horticulture; and
    - up to 6 credits from fields of science not prescribed in the Major requirements; and
    - 3 credits from a course at the 3000 level or higher.
- Cumulative GPA of 2.0 or higher
- At least 50% of all courses for the BSc, and at least 66% of upper-level courses for the BSc, must be completed at KPU (See the Laddering and Transferability for more details).

See Appendix A for a full list of the course requirements for the PMT program (including course numbers and titles).

Transferability

As mentioned above, the program aims to attract students who have completed (fully or partially) their first year at another post-secondary institution. KPU is a member of the BC Council on Admission and Transfer (BCCAT) which manages articulation agreements between post-secondary institutions across BC. As such, most of the PMT program’s first-year courses have existing course articulation agreements with many post-secondary institutions across BC (see Figure 1). The only first-year course that does not articulate is PHYS 1600 Introduction to Modern Technology, which was specifically designed for the PMT program. Students from other institutions are also able to transfer a limited number of second year Physics and Math courses for credit toward the PMT degree. The relatively small number of institutions with transferrable second year courses is because many smaller institutions do not offer second year Physics courses, and many of the second-year courses were uniquely designed for the PMT program.

	ALEX	BCIT	CAMO	CAPU	CCC	CMTN	CNC	COLU	COTR	DOUG	LANG	NIC	NLC	OC	SELK	SFU	TRU	TWU	UBC	UCW	UFV	UVIC	VCC	VIU	YUKO
BIOL 1110	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓			✓	✓	✓		
CHEM 1110	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
CHEM 1210	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
ENGL 1100	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MATH 1120/1130	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MATH 1220/1230	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PHYS 1101/1120	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
PHYS 1102/1220	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
PHYS 1600																									
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MATH 2821									✓																
PHYS 2010										✓			✓			✓		✓							
PHYS 2030										✓				✓					✓						
PHYS 2040								✓									✓								
PHYS 2100																									
PHYS 2420			✓					✓					✓				✓	✓							
PHYS 2600																									
PHYS 2610																									

Figure 1: Transferability of first- and second-year PMT courses to and from other BC institutions. Check marks indicate existing articulation agreements.

Preparation for graduate school

Although preparing students for graduate studies is not the primary goal of the program, it is desirable to make sure that laddering into graduate school is an option for our graduates. To facilitate this option, an understanding was reached with the graduate chair of the SFU physics department on how PMT graduates could become eligible for entry to SFU's graduate program. To enter the SFU graduate Physics program, PMT graduates are first conditionally accepted and then required to complete three additional fourth-year theoretical physics courses at SFU prior to full acceptance. So far two of our graduates have pursued that route. UBC have also been contacted about admission of our graduates to their graduate program. They encourage applications from PMT graduates.

1.2. Program Department

The Department of Physics, Astronomy and Engineering has operations on three campuses; Richmond, Surrey, and Langley, with 17 full-time faculty, lab instructors and staff.

The Department offers courses to support the Engineering First-Year, Environmental Protection Technology (EPT), PMT and other bachelors' programs in other science disciplines, as well as breadth courses for non-science students. At the Richmond and Surrey campuses, we offer a comprehensive selection of first year and preparatory physics courses. To support the Engineering First-Year program, a number of Applied Science courses (APSC 1124, 1151 and 1299) are offered on both the Richmond and Surrey campuses, in addition to a specialized Engineering Mechanics course, PHYS 1141/1170. The

Department also runs introductory Astronomy courses for non-science majors, which have been particularly popular with Arts students. The Department has recently started offering an astrophysics course for science students. At the Langley campus, the Physics department runs two courses annually, *Energy, Environment, Physics (PHYS 1400),* and *Environmental Physics Lab (PHYS 1401)*, for students in the Environmental Protection Technology program. The first year of the PMT program is run at both the Richmond and Surrey campuses. All second, third- and fourth-year Physics courses are delivered at the Richmond campus only.

There are nine full-time faculty, five full-time lab instructors and two full-time technicians. The faculty and lab instructor contingents are augmented by part-time personnel as needed. Roughly half of the Department is based in Richmond and half in Surrey; however, the lab instructors and faculty are routinely called upon to teach on both campuses based on expertise or timetabling logistics. In addition, there is a full-time instrumentation specialist on the Richmond campus to support the needs of the PMT program.

1.3. Program Purpose

The purpose of the program is to provide an applied and hands-on education that prepares students for careers in the tech sector.

Changes Since Program Launch

Since program launch, the program has been adapting to meet the needs of its stakeholders. These changes have not altered the program significantly. While some changes have been procedural, others have been curricular, requiring Senate approval. Some of the revisions are outlined below:

CHANGES THAT REQUIRED SENATE APPROVAL:

Issue to be addressed	***Resulting program change(s)***
The senior project was originally completed in one semester. However, discussions within our department and with our Program Advisory Committee led us to the conclusion that a two-semester project would be more beneficial for our students as it gives them more time to plan their project, would allow them to work on a more substantial project, and would increase the likelihood of achieving the desired outcomes.	The senior project was lengthened from one semester to two semesters in duration. PHYS 4199 (semester 1) largely involves project proposal, planning, and management, while PHYS 4299 (semester 2) involves the actual project work.
PHYS 4010 was originally intended to cover both quantum mechanics and solid state physics. However, it became apparent that it would be very difficult to fit both topics into one course. We realized that it makes more sense to give students a firmer foundation in quantum mechanics and to offer a separate course in solid state physics.	PHYS 4010 is now dedicated to quantum mechanics and PHYS 4700 was changed from "Spectroscopic Instrumentation" to "Solid State Physics: Theory and Practice".

Issue to be addressed	*Resulting program change(s)*
The list of recommended business electives on the PMT calendar page contained some courses that had been discontinued.	Discontinued courses were removed from the list.
After the initial offerings of some of the second-year courses it was realized that some course names and prerequisites should be changed to better reflect their content and requirements as well as to provide more flexibility to students.	MATH 2721 is no longer a co-requisite of PHYS 2010. PHYS 2600 and PHYS 2610 are no longer co-requisites. Name of PHYS 2600 changed from "Electronics with Microcontrollers" to "Electronics".

OTHER CHANGES:

Issue to be addressed	*Resulting program change(s)*
Students must work full-time for at least 14 weeks in a relevant department-approved position in order to satisfy the mandatory work experience requirement. This is intended to take place at the end of a student's third year in the program. In order to accommodate work terms longer 14 weeks, the three 3rd-year Spring semester courses are accelerated. Originally the accelerated courses finished at the end of February, so that students could have up to six months (March to August) for their work term. However, feedback from faculty and students indicated that the semester was too demanding in this format.	The accelerated courses now run until mid-March, which decreases the time-pressure, while still allowing for longer work terms of up to five months. PHYS 3710 (Applied Optics & Optoelectronics) was moved from the Spring to the Fall semester as it was deemed to be too demanding to run in accelerated mode. It was replaced in the Spring semester with PHYS 4900 (Special Topics).
Lower enrollment in 3rd and 4th year courses.	We have been running the third- and fourth-year courses in alternate years. This has ensured healthier enrolment in those courses, with third- and fourth-year students taking them together.

External Accreditation

There is no external accreditation for physics degrees in Canada. This issue was discussed several years ago by physics department chairs from across Canada at the annual Canadian Association of Physicists Congress. As far as the authors of this review are aware, the conversation has not progressed any further, but it is something we will keep track of and ensure our involvement in.

Although there is no external accreditation of physics degrees in Canada, the Canadian Association of Physicists does have a Professional Physicist (P.Phys.) designation that our graduates can apply for after three years of physics-related work experience.

1.4. Issues for Program Review

As Physics for Modern Technology is a relatively new program, this is its first program review. However, since the launch of the program, there have been various issues identified by students, faculty, and the program advisory committee (PAC) that the Department hopes the program review will shed further light on. It is hoped that the following four goals and related issues will be addressed by this program review.

1. Determine whether or not the program is meeting its primary purpose of preparing students for employment in the technology sector.

   The following are specific employment-related issues/questions that have been identified:
   - Career progression: Are students progressing in their careers? Are there things related to the program that are holding our graduates back from advancing in their careers? What kinds of upgrades to their education have they been seeking to further advance their careers?
   - Work Experience: Feedback from the PAC has generally been that longer (eight months) work terms are preferred by many companies (though four-month positions are very common). In addition, about 50% of students who have completed their work terms have indicated that longer and/or more work terms would be beneficial (at least as an option, if not mandatory). From time to time, there is also discussion on whether or not a co-op model should be used, instead of coordinating everything from within the Department, which is the current practice.
   - Communication Skills: One career-related topic that is often discussed among faculty and at PAC meetings is the development of students' communication skills. The importance of communication skills is also mentioned often by students in their work experience reports. Although this has been incorporated throughout the program, faculty experience has been that our students need even more opportunity to develop these skills. To that end, the spring 2021 offering of our Special Topics course (PHYS 4900, which students take in their 3rd or 4th year) was on the topic of communication. However, by its nature, the topic of that course changes from year to year. This program review can help determine whether and/or how students' communication skills should be increased in the program.

2. Determine how best to adjust the program curriculum to serve the PMT students' needs.

   Students, faculty, and the PAC have expressed a desire for additional topics to be added to the PMT program. However, any additional topics will require the removal of others. The hope is that this program review will provide quantitative data to support the addition/removal of content from the PMT program. The following are specific curricular issues that we would like to investigate:
   - Computer Programming: Since computer programming is an essential skill for most academic and industrial physicists and technologists, it has always been clear that it must be a skill that students develop during the PMT program. So far, feedback from faculty, students, and the PAC has been that more explicit emphasis on programming is needed, with the likely development of at least one new dedicated programming course focused on programming fundamentals and best practice for scientists and engineers. It is also hoped to incorporate a data science course into the program, and its requirements would help inform the content of any additional programming courses that develop. Although departmental discussions on this topic have already begun and are ongoing, this program review will help identify the best way forward.

- Mathematics: MATH 2721 and MATH 2821 were designed specifically for the PMT program in consultation with the math department. When developing the program, the alternative option was for our students to take at least four existing math courses (in addition to MATH 1120 and 1220). The decision to instead develop and offer MATH 2721 and 2821 was made so that students' math education would be focused on what they need for their 2nd, 3rd, and 4th year physics courses. Recent feedback from the math department has been that it is difficult to cover the content of MATH 2721 in one semester. This program review will be used to determine if changes need to be made to the math content of the program.
- Chemistry: Based on consultations that occurred while designing the program, it was decided to include a total of four chemistry courses in the program. It is important to ascertain whether or not these courses are valued by our graduates and by current members of our PAC (i.e. whether the content is useful in the types of jobs PMT graduates have been securing).
- Breadth: Currently the PMT program requires students to complete 6 elective/breadth courses (18 credits). Two of those courses must be business courses and were included in the program on the basis of feedback from local industry – it was deemed important for graduates to have some business knowledge when entering the workforce. The 18-credit requirement comes from KPU's BSc framework (see Appendix B). It is understood that the BSc framework is due to be revised by the Faculty of Science and Horticulture, partly in light of the new policy AC14 (KPU Credential Framework). The program review will help determine if we can or should change the breadth requirement of the program. Such investigations could in turn help inform the revision of the BSc framework.

3. Identify ways to promote the program and increase enrolment.

   Most of the second, third and fourth year PMT courses have a maximum class size of 20. This is because most of these courses take place in a lab, and lab capacity is more limited than a regular classroom. However, since the PMT program launch, class sizes have been significantly smaller than the maximum. This program review will examine data on class sizes, how they have changed over the years, and how they vary across years one to four. This data will hopefully help identify ways to attract more students.

   - Promotion: Faculty have recently been discussing the need for increased promotion of the program. Earlier, the Department engaged quite regularly in promotional activities, but the level of activity has fallen off. Also, at that time, questions about the kinds of careers that graduates of the program could pursue could only be answered hypothetically. Now that PMT graduates have been securing positions in the technology sector, more concrete material can be included to promote the program and attract students. The Department hopes to identify ways to achieve this goal, internally and in liaison with other groups at KPU (e.g. Dean's office, Future Students Office, Marketing).
   - Transferability: As discussed above, there are gaps in the ease with which students can transfer into the PMT program. An investigation of ways to increase and facilitate transferability from local institutions (and perhaps into our third year) may help to increase enrolment.

4. Identify ways to allow students to pursue other post-degree educational opportunities (i.e. graduate studies).

As previously mentioned, preparing students for graduate studies is not a primary goal of the program. However, there are several current students who are interested in pursuing graduate studies. It is hoped that this program review will give a better handle on the extent of that interest among our student body. This review should also help decide whether and how to further facilitate such opportunities (e.g. through modification of the program and/or the creation of more agreements with other universities).

2. Curriculum Review

2.1. Pathways for Graduates

Pathways to Employment

<u>What kind of occupations are your graduates prepared to pursue?</u>

When designing the program, the expectation was that it would provide a broad education in physics and technology that would allow graduates to pursue scientific and technical roles in the technology sector (in areas such as green energy technology, robotics, industrial process control, and electronics). It was also envisaged that graduates would be prepared to pursue teacher training as well as more business-oriented roles such as technical sales. Now that PMT students have secured work experience positions during the program and full-time jobs after graduation, there are concrete examples of where the program can lead. (See also the Career Pathways Map in Appendix C.)

For their work experience, which takes place at the end of third year, students have secured positions in areas such as robotics, green energy technology, manufacturing engineering, biomedical engineering, software development, physics research, particle accelerator technology, satellite image analysis, optics, agricultural technology, and electronics. Students' roles in those areas have included: assembling, testing, and calibrating products (hardware and software); computer programming; building and testing electronic circuits and optical setups; performing experiments; analyzing data; refining manufacturing procedures. Some students have also gained experience in the area of sales and marketing. After graduating, several students have been offered positions at the company where they did their work experience.

PMT graduates are working in the following areas: scientific camera development; software; scientific research; particle accelerator technology; biomedical engineering; mining technology; electric power supply and management. Job titles of the PMT graduates include: Product Manager; Software Developer; Junior Data Scientist; Hardware Systems Technician; Service Engineer; Biomedical Engineering Technologist; Assembler; Engineering Technologist; Electromechanical Technician.

<u>How are you preparing your graduates for jobs in this field, future changes in this field, and the job market in general?</u>

Preparation for jobs in the technology sector has been the focus of the PMT program from the beginning. The first step in designing the degree was consultation with local companies to determine the type of content that would be useful. This consultation is ongoing through the PAC. Feedback on the usefulness of program content is also received from students when they complete their work experience and from graduates who are employed in the sector.

Specific hands-on technical skills and topics relevant to the technology sector that are taught in the program include electronics, programming, experimental design, process control, sensors & actuators, applied optics, signal & image processing, and analytical chemistry. As noted in the previous chapter, programming is an area that could be improved. Also, there may be a desire to re-examine the range and scope of chemistry needed for the program.

In addition to technical skills, development of students' soft skills is also very important in preparing them for the workforce. To that end, written and oral communication skills are developed in many courses through activities such as report writing, presentations, and teamwork. Recognizing the need for these communication skills to be further developed, this year's offering of our Special Topics was on the topic of communication. The results of this program review will be used to help determine the extent to which communication skills should be incorporated in the program on an ongoing basis.

When designing the program, feedback from employers was that technology graduates are generally lacking in business skills, which are important for many jobs in industry. To help address that, the program contains two business courses. The mandatory work experience at the end of students' third year also helps to prepare them for their future careers. As stated in our Full Program Proposal, the benefits of work experience include "(i) students seeing the relevance of their studies to the workplace, (ii) students gaining valuable experience of the "real world" of employment, and (iii) students making contacts that will serve them well when they look for employment after graduation."

The PMT program helps prepare students for future changes in the field in a number of ways. Although technology may change quite rapidly on the surface, the science underlying modern technology changes much more slowly. Courses such as Classical Mechanics, Thermal Physics, Electricity & Magnetism, Quantum Mechanics, and Solid State Physics, ensure that PMT graduates have a sound grasp of the fundamental science underlying much of modern technology and are therefore equipped to understand and learn about new technologies as they emerge. The PMT program encourages independent learning and thought, which is also important when dealing with changes in the field. For example, in Experimental Physics in second year, students must design and perform their own experiments, as well as learn about topics that are not necessarily directly covered in their lecture courses. This ability is developed further in the 3rd and 4th year projects, in which students carry out extended one-semester and two-semester projects. This requires independent research of the project topic and also often requires students to learn new skills. Such abilities are critical for any employee who needs to keep up with changes in their field of employment.

Are there professional competencies that your graduates require for entry to the profession?

PMT graduates do not require specific professional competencies as set out by an accreditation agency in order to secure the types of position described above.

There is no external accreditation of physics degrees in Canada. As noted previously, the Canadian Association of Physicists does have a Professional Physicist (P.Phys.) designation that our graduates can apply for after three years of physics-related work experience. Although this designation is not required for physicists to work in industry, it is possible that it will help PMT graduates advance in their careers if it becomes more widely recognized.

Are your graduates ready to take on entry level positions only, or are you preparing them in the medium or long-term for leadership roles?

So far, PMT graduates have secured entry-level positions. However, some have advanced to higher levels a couple of years after graduating. In addition, some graduates are planning to pursue further education (e.g. MBA) to accelerate the advancement of their careers. The alumni survey will give more detailed information on the PMT graduates' career paths.

It is hoped that the students' experience in the PMT program will help them as they progress in their careers to more senior roles. In addition to the scientific and technical knowledge that would be important in a senior role in the technology sector, one also hopes that the graduates' problem-solving ability and communication skills will help them as they progress. The alumni survey that will be administered later in the program review process may help identify ways to further help in that regard.

In a competitive employment market, what kinds of experiential education are employers looking for?

The primary experiential learning component of the PMT program is the work experience that students complete at the end of their third year. Although such experience is sought by employers, some members of our PAC have indicated that longer work terms (e.g. 8 months) are more desirable as it gives more time for the student to do meaningful work after the initial training period. Currently the PMT program is structured so that students can do work experience of up to five months' duration. This program review will help inform whether/how to reform the work experience component of the program.

Feedback from the PAC suggests that employers value the experiential learning that the 3rd and 4th year student projects provide. In addition to the specific scientific and/or technical aspects of the projects, PAC members have expressed the importance of development of project management skills, which is now a focus of the first semester of the 4th year project. PAC members also value student projects that are done in collaboration with companies. Some students have been involved in such projects, both as part of their 3rd and 4th year projects and as extracurricular activities.

Will your students be well prepared to keep up with the changing knowledge base of their field?

As discussed above, the PMT program helps in various ways to prepare students to navigate changes in their field of employment. Hopefully this program review will provide further understanding of this aspect of the students' preparation for the workforce.

Pathways to Further Study

Is your program intended to be, in most cases, the terminal program in a student's educational experience, or do you typically expect them to take another program of study?

Since its primary goal is for graduates to find employment in the technology sector, the PMT program is designed so that it can be the terminal program in a student's educational experience. However, as discussed below, options for further study are available to students after they graduate. See also the Career Pathways Map in Appendix C.

Does, or should, your program ladder into another credential at KPU or elsewhere? To what extent are your courses transferable to other programs at KPU or elsewhere?

The program is not designed to directly ladder into other programs. As shown in Figure 1 (Chapter 1), our first-year courses are highly transferrable to other BC institutions. Also, as discussed below and in the previous chapter, transferring to graduate programs at other institutions is possible.

BSc degrees at KPU have a significant amount of overlap in their first year. Students who decide to switch programs after (or during) their first year will therefore have already completed a sizable fraction of the first-year courses.

The first year of our program contains five of the Engineering Certificate's courses, so transfer between the two programs is possible.

Does, or should, your program provide prerequisite courses that allow students to apply, on graduation, for a professional program (such as teacher education)?

As written in the Full Program Proposal: "We believe graduates of our program will be exceptionally well prepared for entry into teacher preparation programs for secondary school science teaching. The program provides a combination of theoretical understanding at a level that appropriately exceeds that required in high schools and practical skills that supports the teacher's work. After the appropriate teacher-training, the more obvious areas of expertise include physics, math, electronics and information & communications technology."

None of the PMT graduates so far has pursued this route. However, one should connect with local teacher preparation programs to confirm that PMT graduates are eligible for admission.

Some of the PMT alumni who are currently employed are planning to register in (or have started) MBA programs. Their analytical and communication skills, along with the business content of the PMT program, will help them in pursuing this route.

Is a graduate of your program well prepared for study at the next level? Is, for instance, a baccalaureate graduate prepared for graduate school should they choose to pursue it?

Although preparing students for graduate studies is not the primary goal of the program, it is desirable to make sure that laddering into graduate school is an option for our graduates. To that end, several years ago the Physics Department reached an understanding with the graduate chair of the SFU physics department on how PMT graduates could become eligible for entry to SFU's graduate program. It involves completion of three additional fourth year theoretical physics courses at SFU. So far, two PMT graduates have pursued that route. The Department has also reached out to UBC, and they have indicated that they encourage applications from PMT students.

Laddering directly into graduate programs outside Canada is possible. One of the recent graduates was accepted into the MSc in Fusion Energy at the University of York in the UK (though chose to accept a job at a BC tech company instead of pursuing the MSc).

The experience of faculty at similar European BSc programs is that their graduates fare very well in graduate school. For example, a graduate of a highly applied and hands-on physics degree is well-prepared for research in laboratory-based experimental physics.

Pathways to an Enriched Civic and Personal Life

How well does your program curriculum develop skills an educated citizen should have?

By the end of the program, students will have a high level of numeracy and a deep knowledge of physics. They will have honed their skills in course work, scholarly research in their projects, and in their work experience. These skills are transferrable and will allow our graduates to evaluate complex issues by looking deep into the data and drawing their own conclusions. The program puts emphasis on communication so they will have the ability to present their findings and opinions in a clear, coherent manner in writing and in public. During the program, students develop the ability to read and understand complex texts and documents, which will serve them well in keeping up to date with, and understanding, many of the major issues facing our society. PMT students will be able to engage in the discussion of complex issues, not just follow them.

As the program name Physics for Modern Technology suggests, PMT students will have acquired a deep appreciation of the new technologies that pervade daily life and will be equipped to put those technologies to work in new and creative ways for their own benefit and the benefit of society. It will also allow the students to better understand the potential and the limitations of new technologies.

Finally, the program makes it clear that there is always more to know. Research and project courses give the students the skills to control their own learning and not to rely on their instructors.

Does your program help students to make more informed decisions in their personal and civic lives?

As mentioned above, numeracy, a sophisticated knowledge of physics and technology, the practice of scholarly research, examining data and drawing conclusions, synthesizing research findings, and being able to present and discuss those findings are skills that can be used in many areas of their personal and civic lives. If the students wish to make informed decisions, they will have the problem-solving skills to do so in many areas.

Does your program equip students with new, or deepened literacies – be they digital, oral, written, etc.?

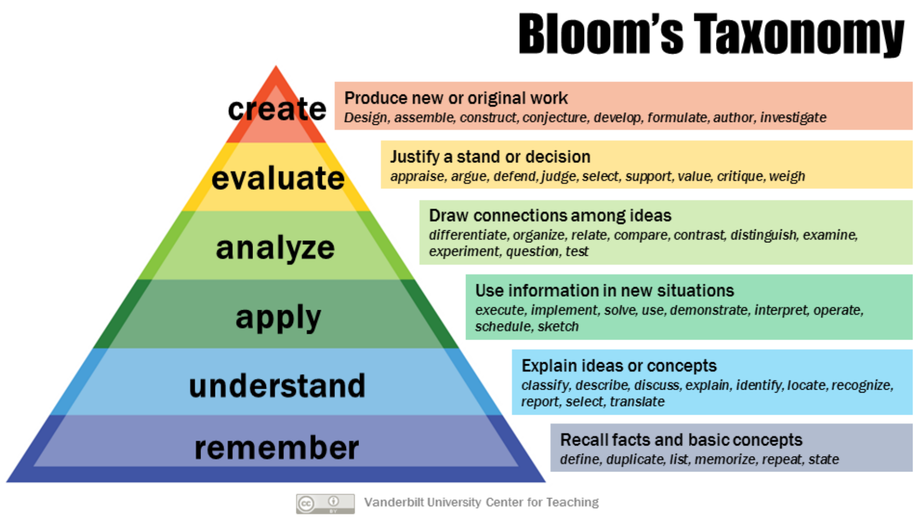
PMT students acquire and use a wide range of mathematical, scientific, and technical knowledge. Numeracy, an often-overlooked literacy, is at the heart of the physical sciences. Combined with a deep knowledge of physics, numerical data, equations, and charts become a way to read and represent the world around us.

Since the program emphasizes communication skills, the students will have had experience translating complex ideas and technical knowledge into more accessible language. To be truly literate, one must be able to discuss topics on many different levels.

2.2. Program Learning Outcomes

Since the PMT program did not have an explicit list of program learning outcomes (PLOs) prior to this review, one of the major tasks of our curriculum review was to develop them.

A list of graduate attributes for the program was first created by the PMT program review team based on continuous feedback from local companies, knowledge of similar programs in Europe, and the vision for the PMT program. A proficiency level was assigned to each attribute according to Bloom's Taxonomy.



Graduate Attribute	Proficiency Level at Graduation
Physics Knowledge	Analyze and Evaluate
Math Knowledge	Analyze and Evaluate
Chemistry Knowledge	Apply
Biology Knowledge	Understand
Communication skills	Analyze
Business	Understand and Apply
Lab techniques and practical skills	Evaluate
Experimental design skills	Evaluate and Create
Analysis and modelling skills	Evaluate
Computer/software programming skills	Evaluate and Create
Cooperation and teamwork attitudes	Apply
Limits of knowledge & independent learning	Apply
Integration of concepts	Evaluate and Create

[Note: even though the process of integrating concepts may create new works, one does not expect the student's ability to integrate concepts to be at the same "create" or "evaluate" level as might be expected for a Master's or PhD thesis.]

This process led to the following PLOs:

A student who successfully completes this program will have reliably demonstrated the ability to:

1. analyze and solve theoretical and practical problems using learned fundamentals and applied Physics knowledge and concepts;
2. analyze and solve theoretical and practical problems using learned fundamentals and applied Mathematics knowledge and techniques;
3. apply learned fundamentals and applied Chemistry knowledge, including laboratory skills and techniques, to solve theoretical and practical problems;
4. understand and gain an appreciation for concepts of Biology as they relate to physics and technology;
5. apply the conventions and best practices of written and oral communication to effectively convey and discuss thoughts and ideas;
6. appreciate the business aspects of the technology sector and technology development;
7. choose, assemble (soldering, connecting, powering, and interfacing components), and operate laboratory equipment to perform experiments and collect data;
8. design laboratory experiments to investigate and/or validate hypotheses by utilizing the conventions and best practices of experimental research;
9. formulate or validate theoretical and/or numerical models by visualizing, analyzing, and evaluating data;
10. use, adapt, and develop software to: interface with equipment; collect, visualize and analyze data; perform numerical analysis; and model physical systems;
11. work cooperatively and effectively with peers and supervisors;
12. recognize the limits of their own knowledge and skills, identify appropriate avenues for new learning, and pursue new knowledge and skills independently;
13. develop solutions to problems by integrating facets of science, mathematics, technology, business, experience, practical skills, and communication skills.

2.3. Essential Skill Development

Both KPU and the Ministry of Advanced Education and Skills Training have lists of essential skills that KPU's programs are expected to meet. Combining these requirements leads to thirteen essential skills that students in our program should have the opportunity to learn and demonstrate:

Creative Thinking and Problem Solving Skills;
Oral Skills;
Interpersonal Skills;
Teamwork and Leadership Skills;
Personal management and Entrepreneurial Skills;
Writing Skills;
Reading and Information Skills;
Visual Literacy;
Mathematical Skills;
Technological Skills;
Intercultural Skills;
Citizenship and Global Perspective;
Independent Learning.

A number of essentials skills are inherent to an undergraduate physics degree. From reading and understanding physics lab manuals, reading graphs, writing lab reports and using algebra and calculus to solve kinematics and dynamics problems in first-year studies, to performing literature searches, analyzing data, writing term papers and solving advanced physics problems using differential equations, complex numbers and vector calculus in fourth year studies, reading, writing, visual literacy, creative thinking, problem solving and mathematical skills are developed throughout a physics degree program.

The PMT program at KPU is more than a standard physics degree and was specifically developed to emphasize practical applications of theory and hands-on experience. The use of technology is prevalent throughout the PMT program, with the introduction of microprocessors in their first year PMT course, and electronics, sensors and actuators, process control, applied optics and practical solid state physics course in the upper years, PMT students are provided many opportunities to develop their technological skills. Much of the hands-on experience comes from the labs where students work in teams to prepare equipment and perform experiments. Team learning in the labs is a common theme in the PMT program, with lab-based courses in each year of study to give students the ability to advance their teamwork, leadership and interpersonal skills. The capstone courses of the PMT program are the third- and fourth-year project courses. These one- and two-semester long projects require students to imagine creative solutions to unique problems. Working independently towards the application of the solutions, students are required to identify gaps in their knowledge base and learn independently to address those gaps.

The PMT program was also designed to facilitate employment after graduation. Public speaking is usually a weakness for most people, so to help develop good oral skills in PMT graduates, oral presentation skills are explicitly listed in the learning outcomes in three PMT program courses, in the first, third and fourth years of study. PMT students are also required to take business electives to aid in the development of their entrepreneurial skills and global perspectives. Probably one of the best mechanisms to facilitate employment after graduation is the requirement that each PMT student complete a work experience term. In addition to gaining experience in a relevant industry, PMT students also gain personal management, intercultural, citizenship and a global perspective while interacting with the world outside of academia.

Nearly all of the essential skills are explicitly addressed in the design of the PMT program and/or the learning outcomes and learning activities of the required courses. However, the KPU essential skill, “Intercultural Skills” has not been formally addressed. Even though the diversity of KPU’s student population and instructional staff provides PMT students the opportunity to meet and interact with people of different cultures, it is felt that more can be done to ensure that the PMT students have an intercultural awareness, particularly with respect to Indigenous peoples.

2.4. Curriculum Assessment

The complete course requirements for the PMT program are listed in Appendix A. The full curriculum map, in which we have listed course learning outcomes (CLOs) for each course and identified which PLOs they align with, is presented in Appendix D.

As mentioned above, the program PLOs were developed for this review based on the content and desired outcomes of the program (an explicit list of PLOs did not exist prior to this program review). The curriculum mapping exercise has shown that the PLOs are appropriate and are well-covered by the program as a whole. The map demonstrates that the level at which the PLOs are addressed progresses appropriately from an introductory (I) level in 1000-level courses to developing (D) at intermediate levels and mostly advanced (A) at the upper level. Since the prerequisites and corequisites for program courses were designed to allow students to progress smoothly from one level to the next, there were no concerns about their overall appropriateness.

Gap Analysis

Some apparent gaps in how the CLOs map to the PLOs are discussed and explained below.

PHYS 2420
Two of the course learning outcomes are not addressed at all in the curriculum map. This is because the course was developed and taught well before the PMT program was launched and the content on AC circuits and semiconductor devices is now covered in PHYS 2600 instead. This points to the need to revise the PHYS 2420 course outline.

PHYS 4900
This is a Special Topics course, with the topic varying from offering to offering. Due to this variation, a specific mapping of CLOs to PLOs cannot be achieved. We may need to revise the CLOs for this course so that they can cover a wider range of possible topics.

Business
The two business courses that students must take to complete the program were not included in the curriculum mapping exercise because there are many courses that can be taken to satisfy this requirement. Despite this, PLO #6 ("…appreciate the business aspects of the technology sector and technology development") is still represented in the curriculum map (CLOs from PHYS 3900, 3950, 3951, 4199, 4299, and 4600 are connected to this PLO).

Recommendation:
Update the PHYS 2420 and PHYS 4900 course outlines to better align them with current practice.

3. Program Relevance and Demand

3.1. Relevance

Are the program learning outcomes relevant to the current needs of the discipline/sector?

The primary goal of KPU's PMT program is to prepare students for a career in the high-tech sector. While some students may have other plans after graduation, such as graduate school or a different degree, this review will focus on the primary goal of the PMT program, specifically, on its relevance to the major stakeholders of the program – students and industry.

Based on the student and alumni survey responses [Appendices F and H], both students and alumni felt that the PMT program was relevant to their career goals. Current students, who were at various stages in the program, all responded positively to the general question on program relevancy – 100% either somewhat or strongly agreed that the program was relevant to their career goals. Alumni, who had all completed the program, were afforded an opportunity to provide a more detailed assessment of the PMT program. For nine out of the thirteen program learning outcomes (PLOs) listed in chapter 2, 75% or more of the alumni responses were positive (either somewhat or very relevant). For three of the PLOs, related to chemistry, communications and business, the alumni responses were still mostly positive, but only 62% of the alumni found these learning outcomes to be relevant. Only one PLO, related to biology, yielded a majority of negative responses to its relevancy. In terms of the PMT curriculum, a very high fraction of both current students and alumni, 92% and 100%, respectively, were either somewhat or very satisfied with the PMT curriculum. Regarding the strengths of the PMT curriculum, two main themes emerged from the open-ended responses. Over half of the respondents specified "hands-on" learning and training as a strength of the program, with specific mentions of the labs and projects. The other strength of the PMT curriculum, as noted by nearly half of the respondents, was the variety of topics and courses included in the PMT program. Students and alumni were also asked for suggestions to improve the PMT curriculum. While a number of suggestions were related to class scheduling rather than curriculum, the ideas of including more computer programming and statistical topics was noted by multiple respondents. Astronomy and astrophysics were also suggested.

The other major stakeholder of the PMT program – industry – also deemed the program to be relevant to their sector [Appendix I]. The replies from industry regarding the importance of the PLOs closely mirrored the alumni responses. In fact, for the same nine PLOs rated most favourably by the alumni, 75% of the industry respondents also deemed these PLOs to be very important or essential. The only difference in the responses between alumni and industry was with regards to the communication PLO. Eighty-eight percent of the industry respondents considered communications to be very relevant, compared to 62% of alumni. With regards to the PMT curriculum, many of the skills, training and knowledge identified by industry are already part of the PMT program. Skills such as programming, soldering, electronics, motor control, business practice, presentations/communications, hands-on experiences and working in a team environment are part of the PMT course and program learning outcomes. In order to maintain relevancy in the future, the industry survey also asked respondents to identify emerging trends in their sector. Technology related to addressing climate change (renewable energy, sustainability, carbon capture), and automation (artificial intelligence, machine learning, quantum computing) were identified as important themes in the coming years. While elements of these themes can be found in some of the course learning outcomes, it may be worthwhile to update the course outlines to explicitly address these topics.

Faculty responses [Appendix G] were in strong agreement (100%) that the PMT program prepares students for a career in the high-tech sector and that the PMT program is relevant to the needs of the sector. The detailed responses from faculty regarding relevancy of the PLOs and curriculum closely mirrored the views of both alumni and industry. Faculty commonly communicate with students and industry, so it is not surprising that the responses from faculty reflect these conversations. In common with students and alumni, several faculty also expressed the need for the computing content of the program to be strengthened (Q7 faculty survey). One faculty member also suggests restructuring the mathematics content of the program. Similar issues with computer programming and mathematics were also identified by the program review team in chapter 1 prior to the launch of the surveys.

Current students, alumni, industry and faculty all agree that most of the PLOs of the PMT program are relevant. Alumni, industry and faculty viewed the biology related PLO to be significantly less relevant than the other PLO's, with less than 50% of the respondents supporting the relevancy of biology.

Recommendations:

As noted above, survey responses suggest that a review of the program's curriculum is warranted in order to increase its relevance. These include both changes to existing content of the program as well as suggestions for new topics to include. Several of the areas of potential curricular change (computer programming, biology, and mathematics) that were identified in the surveys were also identified by faculty in chapter 1 prior to the administering of the surveys. We have the following recommendations:

- Assess whether or not the biology content of the program needs to be changed. Although there have been good reasons for including biology in the program (such as ensuring alignment with KPU's BSc Framework, providing breadth of education, and preparing students for potential careers in the biotechnology sector), the survey results suggest that the biology requirement and its relevance to the program should be reviewed.
- Investigate ways in which the computing content of the program can be strengthened. The need for this is a common theme among survey respondents and has also been identified by faculty prior to this program review (with some work on looking into the issue already begun).
- The faculty survey points to the need to review the content and structure of the mathematics component of the program. The need for this was also identified by faculty prior to the surveys.
- Investigate the suitability of the new topics that were identified by survey respondents for inclusion in the program. These include: clean technology; artificial intelligence and machine learning; data science; RF (radio frequency) technology; statistics; statistical physics; astronomy/astrophysics.

The PAC should be consulted on any revisions before implementation. In addition to the topics identified here, the PAC should also be surveyed regularly on potential topics to ensure the program stays relevant.

Does the program have the connections to the discipline/sector needed to remain current?

Professional academic bodies

Faculty in the department are active members of the Canadian Association of Physicists (CAP), the BC Association of Physics Teachers (BCAPT), the American Association of Teachers (AAPT), and the Canadian

Astronomical Society (CASCA). Activities include attending and presenting at conferences and serving on committees. As well as individual memberships, we also have departmental membership of CAP.
Faculty also hold leadership positions such as President of the BC Association of Physics Teachers and section rep for BC in the American Association of Physics Teachers. Until recently, was also the Secretary/Treasurer of CAP's Division of Physics Education. These connections ensure that faculty remain current in latest trends and best practices in their field(s), especially when it comes to teaching.

Professional industry associations

- For several years, at the instigation of the physics department, the Faculty of Science and Horticulture has been a member of the BC Tech Association. This has proved to be beneficial for making connections with local tech companies. Our students have also been able to attend networking events organised by BC Tech. All of this has helped to build our profile with, and maintain connections with, local industry. However, membership and connection with the association have lapsed in the past year and need to be renewed.
- When launching the PMT program, we joined the International Society of Automation, which had a BC section at the time. This facilitated connections with local automation professionals and companies through attending trade fairs, field trips, and social/networking events. The BC section has been inactive for several years but is being reactivated and we are re-establishing our connection with them. Along with the mechatronics program (Faculty of Trades and Technology), we are looking into the possibility of setting up an ISA KPU student section.

Program advisory committee (PAC)

The PAC was established in 2014. Meetings have been held approximately every 18 months since then. Committee members hail from a variety of local teach companies and organizations. They are a very engaged group who have helped the program stay current with latest industry trends and provided advice on program content. The PAC has, on average, met approximately once every 18 months. We will increase this frequency to once per year (the minimum frequency required by KPU's new policy AC1 (Program Advisory Committee).

On-campus events

Some examples of other on-campus events that help to maintain strong connections with the local tech sector:

- Student project presentations and work experience presentations, which several of the program's industry contacts have attended.
- For several years before the pandemic, the physics department hosted a lecture as part of the annual Canadian Association of Physicists Lecture tour, and several industry contacts and PAC members have attended.
- In 2017, representatives from local companies were invited to meet one-on-one with 3rd and 4th year PMT students. The evening had a speed-dating format, and its goal was to give students experience of networking and hopefully secure a work experience position for the summer. This event worked well, and we should consider doing it again, perhaps on an annual basis.
- Before the pandemic the physics department organized and ran two large annual competitions for high school students: the Kwantlen Science Challenge (KSC) in November and the Junior Physics and Engineering Challenge (JPEC) in April. Members of the BC Association of Professional Engineers and Geoscientists (APEGBC) are typically invited to help run the event. Returning to

running these events post-pandemic will be as an opportunity to strengthen the PMT program's connection with local industry.

Connections with alumni

Connection with alumni is maintained in various ways. Last year, an alumnus spoke about the program at an information session organised by the Future Students Office. Last Fall, an alumnus contacted the program about a potential collaborative project with company. This has developed into a capstone project that a fourth-year PMT student is currently working on. Alumni attended the 3rd and 4th year student project presentations in April of this year. Alumni sometimes notify us of employment opportunities for our students. Such notifications have led to both work experience positions for students and jobs for new graduates.

The alumni survey results show that most alumni are happy with the connections they have with the program: 63% of respondents agreed with the statement "I am provided with opportunities to stay connected to the Physics for Modern Technology program" (Question 35). Alumni survey respondents also had some good suggestions for building better connections with them, including: a LinkedIn profile for the program; alumni events; and competitions involving both current students and alumni. These suggestions are certainly worth looking into.

Potential employers

63% of alumni survey respondents agreed with the statement "The program provided me with opportunities to develop connections with industry/potential employers" (Question 35). There is certainly room for improvement on that figure. The avenues described above for maintaining the program's connection with industry tend to be intermittent and are not consistently or systematically pursued. Program faculty should consider making an annual calendar of events and activities so that such opportunities can be provided more consistently from year to year.

The co-ordinator of the PMT work experience courses (PHYS 3950 and 3951) regularly seeks out new potential employers to connect with.

Discipline/Sector Survey Responses

Respondents to the discipline/sector survey also provided us with useful feedback on the effectiveness of the program's connections with industry, including some useful suggestions. 80% of respondents were either very or somewhat satisfied with opportunities to stay connected with the program. 60% said we are very responsive, and 40% somewhat responsive, to external advice. These results suggest that our efforts to maintain connection and dialogue with industry are largely effective and should be maintained. In addition, 93% of respondents were either very or somewhat interested in participating in projects that connect students to the industry. Although there is currently one student project being done in collaboration with a local company, and there have been a number of others previously, this result suggests that it should be possible to increase the number of industry-connected student projects.

Discipline/sector survey respondents also had some ideas for how the program could maintain and strengthen connections with the sector, including inviting scientists and engineers from industry to give talks and arranging field trips for our students to local companies (See Q17 and 21). While we have done some of this in the past, they should become a more regular and more frequent part of our program.

Recommendations:

The above analysis of survey responses and the program's track record of engaging with industry and alumni shows that improvements can be made in this area. We have several related recommendations:

- Renew links with local professional associations such as the BC Tech Association and the BC section of the ISA. This will allow faculty and students to engage in the networking events that are organized by these associations, which will in turn raise the profile of the program and lead to more opportunities (for student work experience, for collaborative projects, and for jobs post-graduation).
- Organize more events, both on- and off-campus. Suggestions from alumni and discipline/sector survey respondents include field trips, invited talks, and alumni/student competitions. We also recommend revisiting the idea of a student-industry networking evening on campus, which was held once several years ago and which could potentially become an annual event. In addition to ensuring ongoing engagement with industry and alumni (which would in turn lead to more opportunities for our students), such extracurricular events would increase the visibility of the program on campus, thus providing an opportunity to attract and retain more of our many first-year students.
- Develop an annual calendar of events. This would include both internal and external events of the kind described above. It would help to keep us accountable and would help ensure that events stay 'on our radar' from year to year.
- Develop a LinkedIn profile for the program to allow us to engage more with industry online. This was suggested in the alumni survey and would be part of a broader effort to have a more substantial and consistent presence on social media in general. This is also related to promotion of the program and will be elaborated on further in that section (see below).

Does the program include appropriate Indigenous content?

When the PMT program was developed and launched, indigenization was not a prominent educational endeavour, but we recognize that it is now a big goal for KPU and the wider Canadian educational community. Although indigenization has not been an explicit goal for the program, the physics department does engage in some related activities:

- A broad range of teaching modes are used, some of which are recognised as ways in which educators can help indigenize and the delivery of curriculum.[1] For example, many classes involve students working on activities together in small groups. In fact, many faculty have moved away from traditional lectures altogether and engage instead in a "flipped classroom" format in which lecture material is delivered through videos and reading assignments, with class time being used for deeper and more collaborative activities such as problem solving in small groups and group discussion. Some faculty also require our students to engage in reflective writing, which is a

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[1] Shauneen Pete, *100 Ways: Indigenizing & Decolonizing Academic Programs*, Aboriginal Policy Studies, Vol. 6 No. 1 (2016). https://doi.org/10.5663/aps.v6i1.27455

writing activity in which students express and reflect on their own understanding of assigned reading.[2]

- One physics faculty member runs a physics workshop at the regular *Open Doors, Open Minds* event, in which Indigenous high school students are invited to KPU to "meet current students and faculty members, listen to engaging keynote speakers, attend mock classes, and learn about KPU's Indigenous Services for Students". This event is also an opportunity to promote our program to the local Indigenous community.

Recommendation:

Faculty should discuss and develop a clear understanding of what indigenization means for the program. We will also seek guidance from KPU's Indigenous Advisory Committee.

3.2. Faculty Qualifications and Currency

What is the collective expertise available to deliver the program?

FTEs

There are 9.6 FTE (Full-time equivalent) of faculty in the department, nine of whom are fulltime. There is one 50% regular instructor and sessional instructors as needed. There are two types of instructional support staff in the Physics Department. The first are our three full-time technical support people (one Instrumentation Specialist and two Technicians). These positions maintain physics laboratory equipment and do not have direct teaching responsibility. The second type is composed of lab instructors responsible for teaching preparatory and first-year laboratory portions of our courses. There are 5.6 FTEs of lab instructors. Five are fulltime and sessionals are hired as needed.

Areas of Expertise

Faculty are physicists by training, several with additional engineering background. Most of the faculty have an instrumentation or experimental background which is vital considering the goal of PMT is to turn out industrial physicists with a wide range of practical and applied skills. Two faculty have backgrounds in Astronomy. This reflects the number of Astronomy courses we offer.

The broad areas of expertise in the department are optics, condensed matter physics, and astronomy.

More specific areas of expertise are: scanning probe microscopy, sensors and sensor development, experimental particle astrophysics, star formation astrophysics, digital signal processing, dynamics and control of non-linear and complex systems, data science, machine learning, data analysis, superconductivity, semiconductor physics, polymers, environmental physics, laser technology, microfabrication, applications of physics in cell biology, fusion energy, and solid oxide fuel cells. As well

[2] Kalman, Calvin S., Lattery, Mark and Sobhanzadeh, Mandana, *Impact of Reflective Writing and Labatorials on Student Understanding of Force and Motion in Introductory Physics.* Creative Education, 9 (4). pp. 575-596 (2018). http://dx.doi.org/10.4236/ce.2018.94041

there is considerable expertise in astronomy education, online physics labs, and physics education and outreach.

Faculty Qualifications

All but one faculty member has a PhD. Since the development of the PMT degree, only PhDs have been hired. Two faculty members have an Engineer-in-Training (EIT) status. This is helpful with successful transfer of our Applied Science courses and students to Engineering programs.

Expertise of Instructional Staff

Among the department's technical support people are two B.Eng. and one MSc. They have expertise in digital electronics and optics.

Among the department's lab instructors, there is one PhD and one MSc with the remainder being BSc holders. Areas of expertise include computer programming and the production and editing of instructional video.

Recent Professional Development

Much of the PD by physics faculty is spent acquiring deeper skills to aid in student research projects such as taking educational leave to learn about fabrication of molecularly imprinted polymers and performing scanning probe microscopy studies of organic photovoltaic materials and taking an online course in Power Electronics. A large part of scheduled PD is self-directed, side of the desk work such as learning javascript to create physics simulations and learning video editing techniques to prepare instructional or introductory videos for labs.

Scholarly presentations have largely grown out of the innovations that the faculty do as part of their teaching including the development of the PMT degree and creating remotely operated labs. Faculty have also made presentations to high school teachers on aspects of teaching physics and to retired learners with a general desire to learn more about physics.

Teaching load is high at KPU but several faculty members have published research in the last five years in Astronomy and Physics Education. One faculty member has also been a reviewer of several papers.

Several members are involved on the organizational side of the Canadian Association of Physicists (CAP), the Canadian Astronomical Society (CASCA), and the BC chapter of the American Association of Physics Teachers (BCAPT).

Collectively, does the department have the expertise needed to deliver the curriculum?

The KPU Physics for Modern Technology degree was modeled on similar degrees in Ireland and with the assistance of the Galway-Mayo Institute of Technology, the Cork Institute of Technology, and the Waterford Institute of Technology. In creating the degree, it was acknowledged that faculty at the time did not have the expertise to offer all the third- and fourth-year courses for the degree. Fortunately, establishing the degree necessitated the hire of two new full-time faculty. These faculty members were hired for their expertise is the required areas. When hired, the new faculty developed most of the required new course outlines. Combined with the pre-existing expertise in the Department, the breadth and depth of specialist knowledge has been more than enough to graduate students from the program with the skills and attitudes that have made our students successful in obtaining employment (see Alumni Survey) and meeting the needs of employers (see Discipline/Sector Survey).

It is worth noting that the breadth of expertise and knowledge in the Department is greater than the curriculum requirements of the PMT program's courses. This extra expertise can on occasion be used in the student project courses (PHYS 3900, 4199, 4299) to enrich the learning outcomes for our students.

Two retirements in the Department following the inauguration of the PMT degree have allowed us to hire new full-time faculty. Prior to the hiring of these faculty, an internal discussion was made of our long-term needs. The department must balance the need for expertise in non-PMT courses such as Astronomy with the need to deepen or broaden expertise in areas applicable to the PMT degree. Fortunately, physicists with a background in Astronomy normally have expertise in Optics that is needed in many of our PMT courses. Beyond Optics, we have also been able to add expertise in Data Science and Machine Learning that we wish to incorporate into our degree.

In the next five years, two more retirements can be expected. The department will of course need to ensure that replacement hires fill any gaps that the retirements may leave in departmental areas of expertise. Such retirements also provide an opportunity to add new areas of expertise to the PMT program.

One problem for a small department such as ours is that the expertise to teach a particular course may only reside with a single faculty member. An unexpected lengthy illness or retirement, or an educational leave, could cause major problems. Some basic planning for such an occurrence is needed.

Professional development and scholarly activity such as research is a problematic area at KPU. High teaching loads, limited PD funds, and lack of space for research laboratories limit what faculty may accomplish. As a result, degree programs in the Faculty of Science and Horticulture emphasize student-led research. Limited funding for student research courses is available. Some research projects may be done in collaboration with companies for whom our students have worked. Such collaboration, as a bonus, deepens our connections with industry. Developing and overseeing student project work is one way faculty can remain current in the field. Much of the professional development done by our faculty has been directly related to the need to oversee student project work or to enhance educational outcomes.

As the PMT program grows and becomes better known, donations in kind from industry are occurring. PMT recently acquired a Scanning Electron Microscope this way. Direct purchase of such a device would have been much too expensive for our budget. As a result, faculty can acquire new skills and offer a broader range of research projects to our students.

Acquiring new equipment, particularly of the size of the SEM, causes its own problems. Space is limited on Richmond Campus. In arguing for new space, administration looks at the number of students who would use that space. Boosting our enrolment would strengthen our position.

Recommendations:

- Prior to a new hire, the department should have a discussion on gaps the retirement will create. In addition, the department should have regular discussions with the Program Advisory Committee about topics in physics that are growing in importance to Industry and conversely topics that are declining. These discussions should drive hiring criteria.

- Alternate instructors for second-, third-, and fourth-year courses should be designated. Current instructors should be asked to develop a package of teaching materials such as a detailed course outline, teaching notes, sample examinations, sample projects, and the like. Course instructors and their alternates should meet to discuss the course and the materials. If possible, hiring lists for the courses should be kept for hiring on short notice.

- Research is crucial to the success of students in the PMT program. The Physics Department should continue to have representation on Faculty and Senate committees considering the future of scholarly activity at KPU.

3.3. Student Demand

Who takes the program?

Exhibits 2 and 3 of the Administrative Data Report (Appendix E) are reproduced below. We also used the KPU Strategic Enrollment Data tool to extract data for PMT-declared students as those are students we can definitively identify as being in the program (see Exhibit 2b below).

Female students

Female students typically make up around 15% to 20% of the program's population. Although this is considerably lower than the 50% to 60% in the Faculty of Science and Horticulture, it is similar to the proportion of female physics students at American institutions. As shown on page 19 of the American Institute of Physics' "Roster of Physics Departments with Enrollment and Degree Data, 2020", the number of female physics bachelor's degree graduates has been steadily increasing in the US over the last couple of decades and had reached over 20% by the year 2020[3].

Under-representation of women in physics is a well-known issue[4] and many causes and solutions have been proposed[5]. We should familiarize ourselves with global current thinking and practices in addressing this issue. One possible step that could be undertaken is to consult our female students and alumni about

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[3] Starr Nicholson and Patrick J Mulvey, *Roster of Physics Departments with Enrollment and Degree Data, 2020*, American Institute of Physics (2020).
https://www.aip.org/statistics/reports/roster-physics-departments-enrollment-and-degree-data-2020

[4] Jess Wade, *Why we need to keep talking about equality in physics*, Physics World, August 2019.
https://physicsworld.com/a/why-we-need-to-keep-talking-about-equality-in-physics/

[5] Valerie Jamieson, *Women in physics: Why there's a problem and how we can solve it,* New Scientist, 7 November 2018. https://www.newscientist.com/article/mg24032031-900-women-in-physics-why-theres-a-problem-and-how-we-can-solve-it/

their experiences to see if they could shed light on barriers to female students entering our program. For example, it is possible that the large gender imbalance among PMT faculty and the subsequent dearth of female faculty role models might discourage some female students from pursuing the program. To that end, we recommend that faculty undertake an investigation into the issue of gender diversity in the department as a whole (students, faculty, and staff) to try to identify strategies for redressing the imbalance. Potential sources of help in this area include groups like the Canadian Association of Physicists' Division for Gender Equity in Physics, which advocates on this issue.

Age of students

Although the age profile of intended and declared PMT students is similar to that of FSH (70-80% aged 22 or younger), exhibit 2b shows that students aged 23 or older typically make up more than 50% of our *declared* total. This could be due to a variety of factors (time to decide on program, students working etc.) and is not considered to be a problem. Having slightly older students in class can benefit the whole class due to the positive influence that their maturity can have on younger students in terms of motivation, study habits etc.

International students

Since 2018/19, the proportion of international students in the program has been significantly lower than in FSH as a whole. Since our program is applied and job-focused, it should be attractive to international students who want to pursue a career in Canada. A reasonable goal for PMT would be to reach the FSH average of approximately 35%.

Exhibit 2: Demographic Profile of Physics for Modern Technology Program Students by Academic Year

	2016/17	2017/18	2018/19	2019/20	2020/21
Student Headcount	*118*	*138*	*114*	*102*	*81*
% Female	18%	19%	13%	17%	16%
% 22 years or younger	76%	83%	77%	72%	72%
% International	22%	24%	18%	18%	17%

Exhibit 2b: ***Demographic Profile of <u>Declared</u> Physics for Modern Technology Program Students by Academic Year***

- from KPU Strategic Enrolment Management Data (files: 2016-17 and 2020-21)

FTE Head counts

Academic Year		**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21**
Total PMT Students		16	9	11	14	13	19	21
Home	Domestic	13	7	9	14	13	17	19
	International	3	2	2	0	0	2	2
Gender	Male	14	7	9	12	11	16	17
	Female	2	2	2	2	2	3	4
Study	Full-time[1]	15	8	9	14	11	17	19
	Part-time	1	1	2	0	2	2	2
Age	<19	5[3]	0	1	0	0	0	0
	19-22	6	4	5	5	5	10	9
	23-29	4	4	4	7	7	8	11
	> 29	1	1	1	2	1	1[2]	1[2]

[1] Full-time defined as at least 9-credits in a semester or at least one term.
[2] This student was 40+ and considered full-time.
[3] This may be the number of physics-intended, rather than PMT-declared students. Students can only declare into the program after completing a minimum of 24-credits, including ENGL1100, MATH1220 and PHYS1220 – typically requires completing at least one undergraduate year.

Exhibit 3: Demographic Profile of Faculty of Science and Horticulture Students by Academic Year

	2016/17	2017/18	2018/19	2019/20	2020/21
Student Headcount	*2,591*	*3,256*	*2,795*	*2,672*	*2,405*
% Female	53%	58%	55%	56%	58%
% 22 years or younger	73%	78%	76%	75%	74%
% International	18%	38%	36%	35%	34%

Students' reasons for taking the program

Out of thirteen respondents to question 4 of the student survey ("What was your main reason for enrolling in the Physics for Modern Technology program?"), eight said they enrolled in the program for career reasons (to prepare for a specific career or to improve job prospects/earning potential). Two enrolled to prepare to transfer and two to prepare for graduate studies. These responses are not surprising given that the program was primarily designed and is promoted as one that prepares students for a career in the tech sector.

Is demand for the program sustainable?

PMT enrollments and comparisons with FSH as a whole

As can be seen in Exhibit 7 of the administrative data report, enrollment trends across all PHYS courses taught by the department (i.e. including the many students who are in our preparatory and first year courses but not in the PMT program) are similar to those across FSH as a whole, with an average fill-rate for PHYS only about two students less than for FSH.

The size of the PMT program itself (as distinct from courses taken by PMT and non-PMT students) can be estimated from the number of declared students (Exhibit 5). Although our relatively new program is still small, it is growing, with a 91% increase in declared students from 2016/17 (11 declared students) to 2020/21 (21 declared students). Growth in enrollments in physics programs is also seen at other BC post-secondary institutions (see Exhibit 6), although we only have data up to 2018/19. Our aim is to have this upward trend continue and we believe that a realistic medium-term goal is to have enough students to run 3rd and 4th year courses concurrently (at least 10 students in our 3rd and 4th year courses, including an increased proportion of international students).

[Note on terminology: to be consistent with the nomenclature in the administrative data report, in some sections of this report we refer to first-year as L1, second-year as L2 etc. Also, we sometimes use the term "upper-level" to indicate 3rd and 4th year (i.e. L3 and L4).]

While the number of declared students has been increasing, the size of the pool from which declared students are drawn (i.e., the number of intended or undeclared students) has been decreasing, with a 43% drop from 2016/17 to 2020/21 (Exhibit 5). The department has identified this as an issue that needs to be addressed and is beginning to make more vigorous efforts to promote the program to intended/undeclared first-year students. The need for this is also seen in the L1-to-L2 retention rate, which is low compared to FSH (Exhibit 8.1 and 8.2). [However, we note that there are two-year programs in FSH that would inflate the L2 FSH numbers relative to ours.] Note that the ratio of declared to intended or undeclared has been increasing, which is a positive sign.

As has been mentioned, the program's upper-level courses have been running in alternate years, with all 3rd and 4th year students together generally taking L3 courses one year and L4 courses the following year. Since there are some exceptions to this, with some L3 courses being offered in an L4 year and vice versa[6], when comparing our upper-level enrollments with those of FSH (for example) it makes more sense to compare PMT L3+L4 totals with FSH L3+L4 totals for any given year. Also, in order to make a direct comparison between upper-level PMT enrollments with those of FSH as a whole, we can use data from Exhibit 8 in the administrative data report to calculate enrollment per class (as opposed to just looking at total enrollment):

2020/21	PMT	FSH
L3+L4 total enrollment	76	887
L3+L4 classes	9	90
Enrollment per class	8.4	9.9

Note that for 2020/21 the combined L3 and L4 enrollments per class for PMT are similar to those for FSH (8.4 vs 9.9). This shows that the practice of alternating our L3 and L4 offerings brings PMT's upper-level enrollments roughly into line with the FSH average. As noted, we hope to at least double our upper-level enrollment in the coming years so that we can offer all L3 and L4 courses every year instead of alternating them.

Another way to assess the health of our upper-level enrollment in comparison to FSH as a whole is to look at the total L3+L4 enrollments as a percentage of L1 enrollments:

2020/21	PMT	FSH
L1 total enrollment	548	6494
L3+L4 total enrollment	76	887
(L3+L4) as percentage of L1	13.9%	13.7%

As can be seen from the above table, retention of L1 students through to upper levels (L3 and L4) in PMT is very similar to FSH as a whole. Despite this, a retention rate of approximately 14% is low and, as discussed, is something the program needs to address.

Financial considerations

[6] For example: PHYS 3950 and 3951 (Work Experience) run every year; PHYS 4900 (Special Topics) is generally offered with L3 courses; students can do their 3rd year project (PHYS 3900) when L4 courses are being offered; and students can do their 4th year project (PHYS 4199, 4299) when L3 courses are being offered.

We identify two ways in which financial considerations can have a positive impact on the sustainability of the program:

- Tuition revenue: Since international students pay approximately $2,000 in tuition fees for a 3-credit course, the data in Exhibit 9 shows that an addition of just 3 international students per class (on average), would bring PMT's average revenue per class into line with that of FSH.
- Low non-tuition costs for students: In recent years PMT faculty have been making efforts to keep additional costs low for students. Keeping costs for students low can help improve the sustainability of the program by attracting more students. Examples of these efforts include:
    - Use of OER (Open Educational Resource) materials instead of requiring students to purchase textbooks.
    - Use of the library resources (e.g. accessing high quality textbooks online for free via the library website).
    - Free lab manuals. Several years ago the department moved away from requiring students to purchase lab manuals. Students can now access them at no cost via course websites.
    - Lending students take-home kits. While this has been a practice for several years in some PMT courses (for example PHYS 2600 – Electronics), it was expanded greatly during the pandemic to ensure students were still able to perform hands-on activities, which are such an important aspect of science education.

  These initiatives allow some PMT courses to be designated as ZTC (Zero Textbook Cost). ZTC is a KPU initiative which "helps remove barriers to access post-secondary education, adapting our programs to create a more equitable place for all students to learn."

<u>Industry demand</u>

Another aspect of demand for the program is industry's need for its graduates. All sixteen respondents to question 14 of the discipline/sector survey said that there is demand in their sector for graduates of programs like PMT, with 81% saying there is "some" demand and 19% saying there is "a lot of" demand. Additionally, 69% percent of respondents said demand is likely to increase over the next 5 to 10 years, while 31% said demand will likely stay the same (question 15 of discipline/sector survey). These responses bode well for the job prospects of future PMT graduates.

The demand for graduates of the program can also be seen in the success they are having in securing jobs. Six out of eight alumni survey respondents say they are currently employed in a field related to what they studied at KPU (with the survey suggesting that the other two have pursued graduate school). Of those six, five are in a full-time position and one is in a contract position. As seen from responses to questions 28 and 29, alumni are working in a wide variety of roles in the tech sector, with job titles of Manufacturing Technician, Software Developer, Cyclotron Operator/Engineering Technologist, Data Scientist, and Hardware Systems Technician. In addition to survey respondents, we are aware of other alumni who are working as Manufacturing Technician, and others in the roles of Electromechanical Technician and Technical Support. One of our alumni, who started off in the role of Product Manager after graduation, has been promoted to the position of OEM Business Development Manager.

<u>Comparison with enrollments at other BC institutions</u>

The number of declared PMT students in 2020/21 is similar to the 2018/19 data we have for smaller physics degree programs in BC (Exhibit 6). In that year, there were 20 declared physics students at

Thompson Rivers University and 29 at UNBC. The number of PMT graduates is also similar to those institutions (see Exhibits 18 and 18.1).

Recommendations:

- We recommend that faculty undertake an investigation into the issue of gender diversity in the department as a whole (students, faculty, and staff) to try to identify strategies for redressing the imbalance.
- To help achieve this goal of reaching the FSH average of 35% international students, we should learn more about how KPU recruits international students and find out if it is possible for KPU's international recruiters and agents to promote our program more abroad.
- Since the low retention rate is a Faculty-wide issue, we recommend that chairs and Faculty Council discuss this and initiate a Faculty-wide response. Our department's Faculty Council representatives can communicate the need for this to Faculty Council, and our department chair can bring this up with the other department chairs and program coordinators in the Faculty. (We note that, at the time of writing, these communications have just begun.)

Does the program have the capacity to meet demand?

Instructional capacity

We currently have instructional capacity to meet demand for the program. However, meeting the goal of running all upper-level courses concurrently will require an additional faculty member to be hired. This and related issues are explored more fully in section 3.2 above.

Physical (space) capacity

First-year PMT labs are taught on both the Richmond and Surrey campuses. The program's 2nd, 3rd, and 4th year labs are largely taught in room 3310 on the Richmond campus, which can also accommodate up to 20 students. For the last few years, the program has also had access to project and workshop space that has allowed students to engage in active hands-on project and fabrication activities that are very important for their employability. The recent loss of the project space and adjacent workshop will prove challenging for the program. Replacement fabrication and project space will be required in order to maintain student satisfaction with the program's facilities and the quality of their education, as well as to accommodate the planned increased number of students. We refer the reader to Chapter 5 (Resources, Services, and Facilities), where these issues are explored more fully.

Does the program have effective outreach to ensure demand?

Overall, faculty are keen to increase and improve promotion of the program. In response to question 3 of the faculty survey, only 27% agreed that the program is being adequately promoted, with 47% disagreeing. As one respondent to the faculty survey stated: "The program is not being promoted the way it should. There is a huge capacity here and I don't think the importance of the program is well advertised. Students would gain skills that are directly applicable to industrial needs. This alone should attract students not only within Canada but also across the globe” (Q7 faculty survey). A similar comment was made in response to question 8 of the student survey: “advertise it more so people would know about it. I found it by chance and didn’t know beforehand that it existed.”

Promotion has two facets: (1) attracting students and (2) promoting to industry to raise the program’s profile and help facilitate opportunities for our students and graduates.

Attracting students

As shown in Exhibit 5.1 of the administrative data report, and by our earlier analysis of retention rates, there is a large untapped potential for increasing the number of students in the program through better retention of current KPU students. The department has therefore identified a need to promote the program more to existing KPU students and has begun discussing how to do this (for example through more explicit promotion of the program to students in our first-year courses). As discussed above, we also recommend a Faculty-wide response to tackle this.

Of course, it will also be important to continue promoting the program to high school students. The need for this is borne out by the fact that in response to question 3 in the student survey, only 23% say they heard about the program via a KPU visit to their high school or via teachers/counsellors. Pre-pandemic, promotion to high school students involved in-person events such as open houses, high school visits, promotion to high school counsellors, attendance at science fairs, as well as large annual competitions that the department organized for high school students such as the Kwantlen Science Challenge and the Junior Physics and Engineering Challenge. Although we have participated in several virtual events during the pandemic, we are looking forward to returning to more in-person promotional events. The Future Students Office at KPU have been very helpful in involving us in their promotions to high schools and we should ensure that we continue to engage with them as more in-person events take place.

Only 8% of student survey respondents said that they heard about the program through social media (Q3 student survey). This tells us that an increased presence on social media will also be an important part of our promotional efforts. This has begun with the recent designation of a faculty member as our social media liaison/facilitator and has resulted in an increased frequency of posts to our facebook page. To help coordinate all of this, we had a recent meeting with our Faculty’s Communications and Events Specialist and will be working with them over the summer (2022) and beyond.

We have also identified international recruitment as a priority. As mentioned above: “A reasonable goal for PMT would be to reach the FSH average of approximately 35%.” To help achieve this, we should learn more about how KPU recruits international students and find out if it is possible for KPU’s international recruiters and agents to promote our program more abroad.

In the past, PMT faculty have promoted to local colleges that do not have their own physics degree and whose students may be seeking opportunities in physics beyond the first- or second-year level. This has involved visits to Langara, Douglas, and VCC. We need to start doing that again.

Promotion to industry

Industry promotion happens through the various events and organizations that were mentioned earlier in this chapter. This is discussed in section 3.1 above.

Recommendations:

As shown, there is great potential to increase enrollments through retention of existing KPU students. There is also a need to engage more with high school students. In light of the space issues identified above, and explored thoroughly in chapter 5, we note that it will be important to have a plan for accommodating the increase in student numbers. In addition to the importance of the Faculty-wide response identified above, we have additional recommendations for how the department can engage in promoting the PMT program:

- Develop a coordinated action plan for promoting our program to students in our first-year classes.
- Engage more with high school students through school visits, involvement in science fairs, and events hosted by us on campus. Seek the support of our Dean's office (e.g. our Faculty's Communications and Events Specialist) and the Future Students Office in these endeavours.
- Develop an annual calendar of events (similar to what was recommended above for our interactions with industry).
- Expand our presence on social media, particularly with a view to targeting potential students.
- Renew promotional activities at local colleges that do not have physics degrees, and whose students may be seeking opportunities in physics beyond the first- or second-year level.

4. Effectiveness of Instructional Delivery

4.1. Instructional Design and Delivery of Curriculum

Are appropriate opportunities provided to help students acquire the PLOs?

As can be seen in the curriculum map that was discussed in chapter 2, most of the program's PLOs are met in multiple courses. This is especially true of the PLOs involving physics knowledge, math knowledge, communication skills, and integration skills. Also very well represented are the PLOs involving laboratory skills, data analysis, computing, teamwork, and awareness of limits of knowledge.

PLOs involving biology and chemistry are less well represented on the map. This is to be expected as they are not core topics in the program. The business PLO also does not feature strongly on the map. This is largely due to the fact that we have not included the two business electives on the map because there are many courses that can be taken to satisfy this requirement.

The results from the student survey largely corroborate the above analysis of the curriculum map. Only 53% of students said that the program helps them develop the business learning outcome to a large or moderate extent. The figure for biology was very similar, at 54%. However, the result for chemistry was significantly larger, with 77% of students saying that the program helps them develop the chemistry learning outcome to a large or moderate extent. For all other PLOs, more than 80% of students say the program is helping to develop them to a large or moderate extent.

Are appropriate experiential learning opportunities provided to help student acquire the learning outcomes?

Responses to question 6 of the faculty survey highlight projects and hands-on work as strengths of the program. We consider a lot of the program's content to fall into the category of experiential learning. As has been previously discussed, the program emphasizes hands-on learning, with more lab-based and fewer theoretical courses than a standard physics degree. The extended 3rd and 4th year student projects are also highly experiential, as is the work experience component of the program. Areas in which students gain work experience have previously been discussed. To give the reader a flavour of the kinds of project that upper-level PMT students undertake, this is the list of projects that were presented by 3rd and 4th year students at the end of the spring 2022 semester:

- LIDAR navigation for a semi-autonomous weeding robot
- Using machine-learning algorithms to classify star forming regions
- Phase-locked loop for quartz tuning fork sensors
- A sun-tracking solar panel
- Soft-actuator pick and place robot
- External-cavity carbon-dioxide laser
- Predicting micro-satellite constellation locations for astrophotography

- Comparison of CMOS and CCD cameras for Raman spectroscopy

As can be seen, students pursue hands-on experiential projects in a wide range of fields including astronomy, sensor technology, clean energy technology, machine learning, robotics, and optics (among others).

Communication skills are another important aspect of experiential learning and those are emphasized throughout the program in the form of oral presentations, poster presentations, report writing, teamwork etc. Survey responses give us confidence that the program is meeting the experiential learning needs of its students:

92% of students and 88% of alumni agree that the program provides sufficient opportunities to reinforce learning through practical application (Q12 student survey and Q14 alumni survey).

A majority of alumni said that work experience (76%) and projects (100%) contributed to their learning to a moderate or large extent (Q15 alumni survey).

An important aspect of experiential learning in the program is the quality of the space, technology, and facilities that allow that learning to take place. Students expressed very high levels of satisfaction with the specialized technology and facilities in the program (Q20 student survey). Although faculty's assessment of this was also mostly positive (Q22 faculty survey), it was not as enthusiastic as the student response – this will be discussed further in chapter 5 on Resources, Services, and Facilities.

Are appropriate opportunities provided to help students acquire the essential skills?

Responses to question 11 of the student survey show that students feel that the program is helping them develop most of the essential skills, apart from leadership skills (31%) and intercultural skills (38%). Although intercultural skills are not something the program focuses on explicitly, students are exposed to people (fellow students and faculty) of diverse backgrounds and from other programs (e.g. School of Design, Sustainable Agriculture). These experiences will serve them well when they go on to work in industry, where physicists work with people with a variety of backgrounds and expertise. This is supported by the alumni survey, where 76% of respondents report that the program helped them develop intercultural skills. Leadership is also not something the program focuses on, however students do gain some project management experience in their fourth-year projects (PHYS 4199/4299), which is an important aspect of leadership. We note that 63% of alumni say that the program helped them develop leadership skills. The difference in the student and alumni responses suggests that by the time they have finished the program, students have gained awareness of how much they have learned in these areas.

Does the program design ensure students are prepared for subsequent courses?

The program has been designed with progression in mind, with prerequisites and content chosen to help students transition smoothly from one level to the next. This aspect of the program's design is borne out in the survey results.

75% of faculty are satisfied with students' preparation for 2000-level courses (Q10 faculty survey) and 83% are satisfied with students' preparation for 3000-level and 4000-level courses (Q12 faculty survey). Overall, 92% of faculty agree that the prerequisites prepare students for more advanced courses (Q15 faculty survey). 92% of students agree that the prerequisites prepare them for more advanced courses (Q13 student survey), and 83% of alumni agree that the prerequisites prepared them for more advanced courses.

Exhibit 17 in the administrative data report also suggests that students are well prepared for subsequent courses. As can be seen in the data for the 2020/21 academic year, mean grades increase significantly as students progress from L1 to L4. In addition, the DFW and repeat rates decrease as students progress from L1 to L4.

Does instruction meet the needs of diverse learners?

The program encompasses many learning and teaching modes. Classes and labs generally involve a lot of student-student and student-instructor interaction and involve activities and modes such as problem solving, group work, lecturing, student presentations, coding, and experiments, to name a few. As such, the program is designed for hands-on, practical, active learners and is less suited to passive learners.

Third- and fourth-year projects are somewhat self-paced and allow students to be more self-directed (especially the fourth-year projects, and with appropriate levels of supervision of course).

Survey results suggest that the program is meeting the needs of our learners:

92% of student respondents agreed that their instructors accommodate their learning needs (Q14 student survey) and 92% of students say they are satisfied with the instruction they have received in the program (Q15 student survey). 92% of faculty agree that "multiple learning modalities are accommodated" in the program (Q16 faculty survey) and 90% are satisfied with the quality of instruction across the program (Q17 faculty survey). In addition, 100% of alumni respondents say they are satisfied with the instruction they received in the program (Q17 alumni survey). Instructors' attention to the needs of each learner is also demonstrated in one student's response to question 16: "Instructors show care to teach each individual student."

Do the assessment methods allow students to demonstrate to what extent they have achieved the learning outcomes?

Instructors' use of a wide variety of assessment methods ensures that there are multiple ways in which students can demonstrate their achievement of the learning outcomes. The types of work and activity that are assessed include written exams, practical hands-on exams, written assignments, oral presentations, poster presentations, formal written reports, reflective writing, laboratory record keeping, and computer programming (coding).

The survey results show a high level of satisfaction with the program's range of assessment methods (Q18 student survey, Q20 alumni survey, Q20 faculty survey). 100% of students and alumni and 91% of faculty agree that the range of assessments let students demonstrate what they have learned. Between 88% and 100% of students, alumni, and faculty agree that information from instructors on evaluation methods is clear and that assessment methods are consistent throughout the program. 100% of students and 88% of alumni agree that instructors provide useful feedback. In addition, 92% of faculty agree that assessment methods align with program learning outcomes.

Summary and Recommendation

Feedback from students and alumni noted above indicates that the current design and delivery of the curriculum and assessment methods in the program are meeting students' needs. We will not remain complacent though. We will investigate ePortfolios as a program-wide self-assessment and a means for students to reflect on their progress.

Recommendation: Investigate ePortfolios as a program-wide self-assessment and a means for students to reflect on their progress.

4.2. Student Success

Are students performing satisfactorily in courses?

A satisfactory grade is considered to be a "C" or above. Exhibits 12 and 13 in the administrative data report represent the cumulative grade distribution of PMT and FSH students, respectively, from 2016/17 to 2020/21. On average, over the last 5 years, 68.6% of PMT students achieved grade C or higher. This result is very similar to the average of 69.8% for FSH students over the same period. In addition, the overall mean grade and repeat rate of PMT students (Exhibits 14 & 15) are very similar to the FSH average. The increase in overall PMT DFW rate in 20/21 (Exhibit 16), as well as the slight increase in repeat rate in that year (relative to FSH), may be explained by the pandemic and the move to online learning, which may have affected physics students more than others in FSH.

While Exhibits 12 to 16 indicate the overall performance of students across all levels of the program, the performance of students in each level (for the 2021/21 academic year) can be gauged via Exhibit 17. Even though Physics is considered to be a difficult subject, Exhibit 17 shows a great improvement of the mean GPA of the students from level 1 to level 4. On its own, this increase in GPA suggests that students are progressing very well from one level to the next. However, the DFW rates at levels 1 and 2 (i.e. first- and second-year) are significantly higher than the FSH average. We could examine pre-pandemic data to try to discern if this is a consistent feature from year-to-year or if it is a result of the change of teaching modes necessitated by the pandemic. We note that the move from in-person to online learning likely had a significant impact on our students due to the hands-on nature of the program.

Are students making satisfactory progress in the program?

The most basic measure of progress through the program is time to completion. Using the data in Exhibit 20 of the administrative data report, it can be seen that the average completion time over the last four years (2017/18 to 2020/21) has been 5.7 years. This is comparable to the average of 5.4 years for FSH bachelor's degrees over the same period (Exhibit 21).

Although PMT students' completion times are not cause for concern, some survey responses suggest that students feel their progress through the program could be faster (Q13 student survey). For example, 54% of students disagree with the statement "I am able to take the prerequisite courses when I need them" and 46% disagree with the statement "The range of courses offered each term is adequate." Although 75% of alumni agreed that the range of courses offered each term was adequate (Q16 alumni survey), several respondents also said that limited availability of courses was a factor in them taking longer than four years to complete the program (Q6 alumni survey).

Alternation of 3rd and 4th year course offerings, as well as the fact that the program's 2nd year courses are only offered once per year, are likely the reasons for low satisfaction with availability of courses. The ability to offer courses more frequently (especially the ability to offer all 3rd and 4th year courses concurrently) will require us to attract more students to the program. As has been discussed, the department is dedicated to growing the program within the next few years, which will allow a broader range of courses to be taught each semester.

Since 2018, when the first student graduated from the program, there have been an average of three graduations per year (Exhibit 18), which is comparable to the graduation rate from physics degree programs at other BC institutions such as UNBC and TRU (Exhibit 18.1). This year, at least six PMT students are expected to graduate, which will be a record year. However, as mentioned, the department is dedicated to further increasing the number of PMT graduates in the coming years.

Are graduates of the program successful?

PMT is designed not to only address industrial needs but also to provide sufficient knowledge for students to continue their education if they desire. This is well reflected in the alumni survey since 75% of respondents are working in industry and 25% decided to continue their educations at other institutes such as SFU, UBC, & BCIT (see Q.21-24 Alumni Survey). Both of the graduates who pursued further education agree that the PMT program prepared them well for further education.

Although the program is designed to prepare students to work in industry, when designing and launching the program we could not predict how successful the program would be in that regard. However, we are proud to see that six out of eight alumni survey respondents say they are currently employed in a field related to what they studied at KPU (the other two having pursued further education). Of those six, five are in permanent positions and one is in a contract position. As seen from responses to questions 28 and 29, alumni are working in a wide variety of roles in the tech sector, with job titles of Manufacturing Technician, Software Developer, Cyclotron Operator/Engineering Technologist, Data Scientist, and Hardware Systems Technician. In addition to survey respondents, we are aware of other alumni who are working as Manufacturing Technician, and others in the roles of Electromechanical Technician and Technical Support. One of our alumni, who started off in the role of Product Manager after graduation, has been promoted to the position of OEM Business Development Manager.

While, in total, 100% of alumni to some extent agree that the program prepared them for industry, 57% of them strongly agree with it. This strength of the program is further underscored in the responses to question 34, where 100% of our graduates say they would be "confident hiring someone … who graduated from this program".

Summary and Recommendation

The feedback above strongly indicates that the current program is meeting its primary objective of training physicists for industry. We will continue to stay in contact with our graduates and the PAC to ensure that we continue to meet this objective. The above analysis also provides us with evidence that can be used as a marketing tool to increase enrolment.

Recommendation: Incorporate more examples of student success into the promotion of the program.

5. Resources, Services, and Facilities

Does the program have the library and learning resources needed to deliver the curriculum?

In general, students report positively on the library services that they use (Q19 student survey). For example, students widely use and are happy with the library's provision of audio-visual and computer equipment, books, ebooks, and online journals, which are probably the most important services to students from faculty's point of view. The lower usage of some items (e.g. DVDs and print journals) can probably be attributed to obsolescence and the wide availability of online resources. Faculty responses showed lower levels of library usage (Q19 faculty survey). However, for those who do use the services, the responses were generally favourable.

Recommendation:

As a department, we should discuss and identify library resources that we might want to use. This could involve a more detailed survey of faculty to find out how library resources are currently used in our 2nd, 3rd, and 4th year courses. This will help us determine if we could be making better use of library resources.

Does the program have the specialized technology needed to deliver the curriculum?

Since the program is very applied and hands-on and aims to prepare students to work in the tech sector, a lot of specialized software and equipment is needed to deliver the curriculum. The importance of equipment and software is also underscored in the alumni survey, in which 100% of respondents said the PLO involving operation of laboratory equipment was relevant to their career goals and 88% said the PLO involving use and development of software was relevant to their career goals (Q7 alumni survey). Some of the program's equipment and software is broadly used in many courses and some is specific to a certain course or courses.

Equipment that is broadly used throughout the program includes standard laboratory instruments such as oscilloscopes, function generators, power supplies, and multimeters. For a list of more specialized equipment that students use, see the table in Appendix J. We also have a library of classroom demonstrations that instructors use to illustrate concepts in the classroom, particularly for first- and second-year courses.

The program also has a range of specialized equipment that is used by students for their third- and fourth-year student projects (depending on the nature of each individual project). This includes, for example, 3D printers, equipment for fabricating microfluidic devices, a spin coater, and a PCB (printed circuit board) printer. Last year the program was also very fortunate to acquire a scanning electron microscope (SEM) by donation from local company Ballard Power Systems, which has so far been used for student projects, class demonstrations, and also by faculty from other departments. At the same time as acquiring the SEM, a sputter coater was also purchased, which is needed to coat samples with a conducting (e.g. gold) film so that they can be imaged with the SEM.

Survey responses are favourable, with 100% of students expressing satisfaction with lab equipment and 90% of faculty saying that the lab equipment meets the program's needs extremely well or very well (Q20 student survey, Q22 faculty survey). In addition, 100% of students and 100% of alumni said that the program is helping them (or did help them) develop the ability to "Choose, assemble (soldering, connecting, powering, and interfacing components), and operate laboratory equipment to perform experiments and collect data” to a large or moderate extent (Q10 student survey, Q12 alumni survey).

Satisfaction with software among students and alumni is also high. 92% of students are satisfied with the program’s software (Q20 student survey). In addition, 84% of students and 100% of alumni said that the program is helping them (or did help them) develop the ability to “Use, adapt, and develop software to: interface with equipment; collect, visualize and analyze data; perform numerical analysis; and model physical systems” to a large or moderate extent (Q10 student survey, Q12 alumni survey). Faculty satisfaction with software is not quite as high, with 60% saying that it meets the needs of the program extremely well or very well (Q22 faculty survey). The department should investigate this further to find out how we can improve in this area and if there is additional software we could be making use of.

Does the program have the facilities needed to deliver the curriculum?

Description of special facility requirements

First-year PMT labs are taught on both the Richmond and Surrey campuses. This includes labs for PHYS 1101/1120, and PHYS 1102/1220, which are taken by students in many programs in addition to PMT, and for PHYS 1600, which is taken by PMT students (but is also open to other students). For these courses, the department has two laboratory rooms on each campus, with each room accommodating up to 20 students. (The same rooms also accommodate some second-year PMT courses as well as labs for the engineering program, preparatory physics courses, and the department's astronomy courses.)

The program’s 2nd, 3rd, and 4th year labs are largely taught in room 3310 on the Richmond campus, which can also accommodate up to 20 students.

Although many of the 3rd and 4th year student projects are housed in room 3310, for the last few years we have had access to project and workshop space that has allowed students to engage in active hands-on project and fabrication activities that are very important for their employability. This was a space where students could leave their projects set up and work on them outside of (as well as during) scheduled project hours (leaving projects set up in room 3310 is problematic as the room is used for many other courses). This space also housed important project equipment such as 3D printers, a PCB printer, microfluidics equipment, chemical storage (fridge and cabinet), and a spin coater (among others), as well as specific student projects that make heavy use of that equipment and that are difficult to accommodate in 3310. Adjacent to the project space is a fabrication workshop, which has allowed the program to meet its metalwork and woodworking needs.

Other specialized space includes room 3260, which houses the recently acquired scanning electron microscope (SEM) and sputter coater. This room also houses a scanning tunneling microscope (used by PHYS 4700 students) and a white light interferometric profilometer, which has been built and used in a number of upper-level student projects. The room has also served as a space for other student projects that require very low light levels. It also houses several telescopes, which are used in the department’s introductory astronomy courses.

The department’s fabrication facilities and space are also used to support many departmental activities beyond the PMT program, including labs for the hundreds of non-PMT preparatory and first year physics students, as well as outreach activities (for example 3D printing parts for demonstrations). Other departments also use our fabrication and workshop facilities for maintenance of their equipment, and they also use our advanced equipment for scholarly activity (e.g. the Institute for Sustainable Food Systems has made use of our SEM)). These represent cost savings for the university as external repair and direct purchases are expensive.

Some student projects (for example, fabrication of microfluidic devices and investigation of polymers) require use of a fume hood for working with chemicals. Although the department does not have a fume hood, the departments of chemistry and sustainable agriculture have been very generous in allowing us to use their facilities.

Some student activities also make use of the wider campus. For example, PHYS 2100 students have mapped the vibrational characteristics of the campus and have also made use of the height of the third floor to perform air drag experiments. In addition, PHYS 4700 students use a section of a common area on the third floor to perform their Earth's Field Nuclear Magnetic Resonance experiments, as it is an area where the local magnetic field is relatively homogeneous (a requirement of the experiment).

An important and growing aspect of our first-year labs is the CloudLab. This allows students to perform labs remotely – they use a computer to log in from anywhere and control equipment that is located on our campus. As well as KPU's first-year physics students, the CloudLab has also been used by students at Langara College and the University of Regina. The experiments, once complete, are housed in several display cases on the Richmond campus. Development space is also needed. Recently, the department was notified that the CloudLab development lab is being reassigned to the new Centre for Entertainment Arts. As of this writing, we are awaiting a replacement room to be assigned to CloudLab.

Survey responses

(Note that the surveys were performed before we learned that we would lose access to the project and workshop space and the CloudLab development space.)

Students express strong satisfaction with the program's facilities: 93% are satisfied with lab space; 85% are satisfied with 3rd/4th year project space; and 85% are satisfied with fabrication/workshop facilities (Q20 student survey). Faculty are less positive: 72% say that lab space meets the program's needs extremely or very well; 50% say the 3rd/4th year project space meets the program's needs extremely or very well (though 20% have not used); 50% say the fabrication/workshop facilities meet the program's needs extremely or very well (though 30% have not used) -- Q22 faculty survey.

Summary and Recommendation

The recent loss of the project space and adjacent workshop will prove challenging for us. Replacement fabrication and project space will be required to maintain student satisfaction with the program's facilities (see discussion of survey results below) and the quality of their education, as well as to accommodate the planned increased number of students. Suitable replacement space for the CloudLab development work will also be required.

Recommendation: Work with and seek the support of the relevant authorities at KPU to ensure the program has sufficient space to maintain quality and accommodate the planned increase in student numbers.

Does the program have the other support services needed to deliver the curriculum?

Both faculty and students were asked about their satisfaction with the bookstore, advising services, career services, and accessibility services (Q23 faculty survey, Q21 student survey). In addition, faculty were asked to rate KPU's support for international students.

<u>Bookstore</u>

Both faculty and students report high levels of satisfaction with the availability of required texts at the KPU bookstore. 70% of faculty said the bookstore meets the program's needs extremely well or very well, with 20% reporting "have not used / don't know". Similarly, 69% of students are satisfied with the availability of required texts at the bookstore, with 8% reporting "have not used". The numbers of "have not used" responses may seem quite high, however this may reflect the fact that many faculty choose to use open educational resources (OER) for some of their courses.

<u>Advising</u>

Of student respondents who have used advising services, satisfaction levels are high. However, it is perhaps surprising that 23% have not used the service. Students are advised to meet with an advisor for declaration and to ensure they plan their courses appropriately. Perhaps the 23% who have not used the service are students who have not yet declared. In any case, it is important for students to meet with advisors early on to help ensure smooth progress through the program.

Faculty also expressed some dissatisfaction with advising. Of those who did not choose "have not used / don't know", only half say that advising services meet the needs of the program extremely well or very well.

<u>Recommendation:</u> Faculty should clarify among ourselves what our expectations are around advising and communicate with advisors about how the service can better meet the needs of the program.

<u>Career Services</u>

Most students (62% of respondents) have not directly used this service, but those who have are generally satisfied. It is likely that most students do not feel the need to contact Career Services as they get a lot of support in that regard from faculty in the program (for example, in searching for and applying for work experience positions). We note that the KPU Career Development Centre has been very helpful in providing workshops to PMT students on writing cover letters and resumes and preparing for interviews.

<u>Accessibility Services</u>

There was a mixed response from faculty and students to the question about accessibility services. A majority of students, and 30% of faculty, have not used the services. It is difficult to gauge the cause of this lack of use since the range of accessibility services provided at KPU is broad.

<u>Support for International Students</u>

80% of faculty responded "have not used / don't know" to the question of how well KPU's support for international students is meeting the needs of the program. This is not surprising, given that only a small fraction of PMT students are international, and faculty do not monitor the immigration status of students.

Recommendation: As part of the effort to increase enrollments, and in anticipation of an associated increase in international enrollments, faculty should familiarize ourselves with the services that KPU provides for international students.

6. Conclusions and Recommendations

6.1. Overview

The curriculum review and self-study that informed this report have been great opportunities for examining the Physics for Modern Technology program in-depth. In some areas we are heartened to see that the program is doing well (for example instructional delivery and student success), in other areas the results are generally positive but with identified avenues for change (for example curriculum), and in other areas where improvement is clearly needed (for example student recruitment and retention) we are happy to have identified ways in which we can improve. In this chapter we briefly summarize the outcomes of each area of exploration and list the recommendations that were proposed in the preceding chapters of this report.

6.2. Curriculum Review

The program's learning outcomes (PLOs) were developed for this review based on the content and desired outcomes of the program (we did not have an explicit list of PLOs prior to this program review). The subsequent curriculum mapping exercise, in which the alignment of course learning outcomes (CLOs) with the PLOs was assessed, has given us confidence that the PLOs are appropriate and are well-covered by the program as a whole. However, we did notice a lack of consistency from course-to-course in the way CLOs are written, both in terms of the number of PLOs (sometimes many, sometimes few) and the level of detail they contain (sometimes very detailed, sometimes lacking detail). When revising course outlines in future, and when writing new ones, faculty should try to ensure more consistency from course to course. Now that we have gone through this exercise, it will be possible to ensure that future new and revised course outlines will align well with the PLOs, which should also result in better consistency. Aside from those important general observations and conclusions, the examination of the CLOs and the curriculum mapping exercise did result in a concrete recommendation to better align the course learning outcomes of PHYS 2420 and PHYS 4900 with current teaching practice in the department.

In addition to the curriculum mapping exercise, our analysis of survey responses when examining the relevance of the program's curriculum in chapter 3 also resulted in some curriculum-related recommendations. These include investigations of potential changes to existing content of the program as well as suggestions for new topics to include. Several of the areas of potential curricular change (computer programming, biology, and mathematics) that were identified in the surveys were also identified by faculty in chapter 1 prior to the administering of the surveys.

We note that the PAC should be consulted on any revisions before implementation. In addition to the topics identified here, the PAC should also be surveyed regularly on potential topics to ensure the program stays relevant. We also note that, depending on what kinds of outcomes emerge from the recommended assessments and investigations listed below, it may be necessary to revisit the program's breadth requirement in order to create room for new topics (or for expansion of existing topics) in the program.

Overall, the curriculum mapping exercise and the examination of the program's relevance have led to the following recommendations:

- Update the PHYS 2420 and PHYS 4900 course outlines to better align them with current practice.

- Assess whether or not the biology content of the program needs to be changed. Although there have been good reasons for including biology in the program (such as ensuring alignment with KPU's BSc Framework, providing breadth of education, and preparing students for potential careers in the biotechnology sector), the survey results suggest that the biology requirement and its relevance to the program should be reviewed.

- Investigate ways in which the computing content of the program can be strengthened. The need for this is a common theme among survey respondents and has also been identified by faculty prior to this program review (with some work on looking into the issue already begun).

- The faculty survey points to the need to review the content and structure of the mathematics component of the program. The need for this was also identified by faculty prior to the surveys.

- Investigate the suitability of the new topics that were identified by survey respondents for inclusion in the program. These include: clean technology; artificial intelligence and machine learning; data science; RF (radio frequency) technology; statistics; statistical physics; astronomy/astrophysics.

6.3. Program Relevance & Student Demand

(As noted above, our analysis of the relevance of the programs curriculum resulted in several recommendations which have been listed in the curriculum review section above.)

Discipline/sector connections

Because the PMT program was designed to prepare students to work in the tech sector, faculty have tried to create and maintain close and multiple connections with local tech companies since the program's inception. Having said that, our analysis of survey responses and the program's track record of engaging with industry and alumni shows that improvements can be made in this area, and we have the following recommendations:

- Renew links with local professional associations such as the BC Tech Association and the BC section of the ISA. This will allow faculty and students to engage in the networking events that are organized by these associations, which will in turn raise the profile of the program and lead to more opportunities (for student work experience, for collaborative projects, and for jobs post-graduation).

- Organize more events, both on- and off-campus. Suggestions from alumni and discipline/sector survey respondents include field trips, invited talks, and alumni/student competitions. We also recommend revisiting the idea of a student-industry networking evening on campus, which was held once several years ago and which could potentially become an annual event. In addition to ensuring ongoing engagement with industry and alumni (which would in turn lead to more opportunities for our students), such extracurricular events would increase the visibility of the program on campus, thus providing an opportunity to attract and retain more of our many first-year students.

- Develop an annual calendar of events. This would include both internal and external events of the kind described above. It would help to keep us accountable and would help ensure that events stay 'on our radar' from year to year.

- Develop a LinkedIn profile for the program to allow us to engage more with industry online. This was suggested in the alumni survey and would be part of a broader effort to have a more substantial and consistent presence on social media in general. This is also related to promotion of the program (see below).

Indigenization

When the PMT program was developed and launched, indigenization was not a prominent educational endeavour, but we recognize that it is now a big goal for KPU and the wider Canadian educational community. Although some of the department's teaching practices align with recognized ways in which programs can decolonize and indigenize, and the department also engages in outreach with the local Indigenous community, we recognize that more can be done to educate ourselves in this area, and we have the following recommendation:

- We recommend that faculty discuss and develop a clear understanding of what indigenization means for our program. We will also seek guidance from KPU's Indigenous Advisory Committee.

Faculty Qualifications and Currency

Our analysis of faculty qualifications and currency demonstrates that faculty and staff are well qualified and well prepared to deliver the curriculum. There is a wide range of expertise in the department that allows a broad range of courses to be taught as well as the supervision of more specialized upper-level student projects. Professional development activities also ensure that faculty and staff are able to remain current in their areas of expertise and in the scholarship of teaching. However, we identify contingency planning (for example for retirements and/or unexpected absences) as an important area in which we can improve. We also identify the importance of research and the need to stay involved in KPU's exploration of the role of scholarly activity in the institution. The following are our recommendations in this area:

- Prior to a new hire, the department should have a discussion on gaps any retirements will create. In addition, the department should have regular discussions with the Program Advisory Committee about topics in physics that are growing in importance to Industry and conversely topics that are declining. These discussions should drive hiring criteria.

- Alternate instructors for second-, third-, and fourth-year courses should be designated. Current instructors should be asked to develop a package of teaching materials such as a detailed course outline, teaching notes, sample examinations, sample projects, and the like. Course instructors and their alternates should meet to discuss the course and the materials. If possible, hiring lists for the courses should be kept for hiring on short notice.

- Research is crucial to the success of students in the PMT program. The Physics Department should continue to have representation on Faculty and Senate committees considering the future of scholarly activity at KPU.

Diversity, retention, and promotion

Our analysis of the make-up of our student body reveals that female students and international students are under-represented in the program. We recommend that the department looks at the underrepresentation of women through a broader gender diversity lens that includes examination of diversity among faculty and staff as well as students. For international students, we believe that the applied nature of our program should appeal to international students who are seeking to pursue a career in Canada. We also note that attracting more international students would have a large positive impact on the revenue generated by the program.

Our analysis of the data also shows that retention of students is low (both in PMT and in FSH in general) and that there is great potential to increase enrollments through retention of existing KPU students. There is also a need to engage more with high school students. In light of the space issues identified (particularly in chapter 5), we note that it will be important to have a plan for accommodating the increase in student numbers.

Overall, our analysis of both the data in the administrative data report and the surveys has led us to the following recommendations for dealing with the issues of diversity, retention, and promotion:

- We recommend that faculty undertake an investigation into the issue of gender diversity in the department as a whole (students, faculty, and staff) to try to identify strategies for redressing the imbalance.
- To help achieve this goal of reaching the FSH average of 35% international students, we should learn more about how KPU recruits international students and find out if it is possible for KPU's international recruiters and agents to promote our program more abroad.
- Since the low retention rate is a Faculty-wide issue, we recommend that chairs and Faculty Council discuss this and initiate a Faculty-wide response. Our department's Faculty Council representatives can communicate the need for this to Faculty Council, and our department chair can bring this up with the other department chairs and program coordinators. (We note that, at the time of writing, these communications have just begun.)
- Develop a coordinated action plan for promoting our program to students in our first-year classes.
- Engage more with high school students through school visits, involvement in science fairs, and events hosted by us on campus. Seek the support of our Dean's office (e.g. our Faculty's Communications and Events Specialist) and the Future Students Office in these endeavours.
- Develop an annual calendar of events (similar to what was recommended above for our interactions with industry).
- Expand our presence on social media, particularly with a view to targeting potential students.
- Renew promotional activities at local colleges that do not have physics degrees, and whose students may be seeking opportunities in physics beyond the first- or second-year level.

6.4. Effectiveness of Instructional Delivery

We are very heartened that our analysis of the surveys indicates that the current design and delivery of the curriculum and assessment methods in the program are meeting PMT students' needs. We will not remain complacent though. We will investigate ePortfolios as a program-wide self-assessment and a means for students to reflect on their progress.

In terms of student success, the survey feedback strongly indicates that the current program is meeting its primary objective of training physicists for industry. The program will continue to stay in contact with its graduates and the PAC to ensure that this objective continues to be met. The success of the program's students has led us to another promotion-related recommendation. When the program launched we could only give hypothetical examples of what kinds of jobs and careers graduates might be able to pursue. Now that the success of PMT students has given us concrete examples, those examples should be used to attract more students to the program.

The following are the recommendations that arose from our analysis of instructional delivery and student success:

- Investigate ePortfolios as a program-wide self-assessment and a means for students to reflect on their progress.
- Incorporate more examples of student success into the promotion of the program.

6.5. Resources, Services, and Facilities

The major issue identified in chapter 5 is the loss of fabrication and project space, which was particularly important for 3rd and 4th year students. Surveys, which were carried out before the loss of the space, indicate a high level of student satisfaction with lab space, project space, and fabrication/workshop facilities. In order to maintain student satisfaction with the program's facilities as well as the high quality of their hands-on education, replacement fabrication and project space will be required. This will also be needed to accommodate the planned increased number of students. Suitable replacement space for the CloudLab development work will also be needed.

In this chapter, we also analyzed satisfaction with the services provided by KPU and how well they meet the needs of the program. The following issues were identified:

Surveys show that students and faculty who use the library are generally satisfied. However, levels of usage are quite low, particularly among faculty.

Knowledge and/or usage of advising services is also quite low, especially among faculty. Among those who have used or know about the services, student satisfaction is high and faculty satisfaction quite low.

In addition, survey results show that the vast majority of faculty are unfamiliar with the services provided by KPU to support international students.

Our analysis of resources, services, and facilities leads us to make the following recommendations:

- Work with and seek the support of the relevant authorities at KPU to ensure the program has sufficient space to maintain quality and accommodate the planned increase in student numbers.

- As a department, we should discuss and identify library resources that we might want to use. This could involve a more detailed survey of faculty to find out how library resources are currently used in our 2nd, 3rd, and 4th year courses. This will help us determine if we could be making better use of library resources.

- Faculty should clarify among ourselves what our expectations are around advising and communicate with advisors about how the service can better meet the needs of the program.

- As part of the effort to increase enrollments, and in anticipation of an associated increase in international enrollments, faculty should familiarize ourselves with the services that KPU provides for international students.

7. Appendices

Appendices are provided in separate document.