Students' reflections on the impact of paid summer photonics research internships

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ABSTRACT

Getting young and talented minds to pursue photonics as a career is a major goal for the optics and photonics community. We have previously reported on a college-university collaboration allowing pre-university science students to engage in university photonics research through paid summer internships. From the university's perspective, this collaboration allows for photonics outreach to students before they choose university programs. From the student's perspective, they are immersed in a scientific research experience for the first time, and they then present their experience in class to the following cohort of college students – this is outreach too. We have surveyed all students who have participated in these paid summer research internships during the first ten years of this collaboration. We report on 1) the survey results to questions pertaining to their learning experience, the training and learning environment, and aspirational elements, and 2) their reflections on the strengths and weaknesses of these internships, such that we can improve the "student experience" for future internships.

Keywords: internships, laboratory experience, outreach, education

1. INTRODUCTION

Encouraging our young science students to pursue photonics as a career is a major goal for the optics and photonics community. However, it is a challenge for the community to encourage enough students to fulfill all photonics related job vacancies. It was recently expressed several times at the SPIE Optics + Photonics conference (2022) that in the USA alone, photonics-based jobs exceed the photonics-based workforce (e.g., [1]). With respect to K-12 education and outreach, we often ask ourselves, "how do we get more students to engage with a meaningful photonics-based experience such that they continue studying and working in photonics?"

We have previously reported on a college-university collaboration allowing pre-university science students to engage in university photonics research through paid summer internships [2]. From the university's perspective, this collaboration allows for photonics outreach to students before they choose university programs. From the student's perspective, they are immersed in a scientific research experience for the first time, and they then present their experience in class to the following cohort of students – this is outreach too. Furthermore, this collaboration includes university lab visits, allowing college students to visit the facilities in small groups and allowing individual day long visits to witness experiments. Last, this collaboration helped facilitate the enhancement of course material linking photonics technology to content studied in the college Waves and Modern Physics course [2, 3].

Between 2012-2022, i) 7 college students have participated in paid summer research internships, ii) Approximately 80 college students have visited the university labs, and iii) over 500 college students (14 classes of ~36 students) have engaged with photonics content during their college Waves and Modern Physics course.

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We have surveyed the 7 students who have participated in the paid summer research internships. We report on 1) the survey results to questions pertaining to their learning experience, the training and learning environment, and aspirational elements, and 2) their reflections on the strengths and weaknesses of these internships, such that we can improve the "student experience" for future internships.

2. PAID SUMMER STUDENT RESEARCH INTERNSHIPS AND SURVEY METHODOLOGY

All the college professor's experimental research is done at McGill University during the summer months. The college professor and students work in collaboration with the university professor, undergraduate, graduate, and post-doctoral students. Considering the college students' limited academic and research experience, it is not expected that college students lead research projects. Hence, a teamwork approach is taken such that the college students can participate in setting up and performing experiments, assisting in data collection and analysis, and presenting the experimental results. They also learn how to use sophisticated test-and-measurement instruments and gain valuable laboratory and research skills that will benefit them in future college and university courses.

The recruitment process for the internships begins in the college Waves and Modern Physics course. Students in the class who are interested in photonics, applied physics, engineering and/or research, and have summer availability are encouraged to speak to the college professor. The internships are very flexible and accommodate the college student: they range in duration from 2 weeks of full-time work to 7 weeks of part time work. To date, no student who wanted to participate in an internship was refused. For students who have shown interest but cannot commit to a summer internship, they are invited to visit the labs and/or join the team for a day.

Table 1 presents characteristics of the 7 college students who have participated in paid summer research internships. 1 student is currently completing their college studies (but is no longer at Vanier College).

Table 1
Characteristics of paid summer research internships participants (N = 7)

Descriptions	f	%
Gender		
Male	6	85.7
Female	1	14.3
College Science student year #		
Year 1	5	71.4
Year 2	2	28.6
Enrolled at McGill University after college		
Yes	6	85.7
Pending	1	14.3
Enrolled in following undergraduate program		
Physics	3	42.8
Engineering (Mechanical)	2	28.6
Engineering (Electrical)	1	14.3
Other science-based discipline (pending)	1	14.3

Note: f, frequency; %, percentage.

The main purpose of the survey was to 1) examine the extent to which students felt they had developed their research skills through their internship and how it affected their choice of university and program, and 2) to get their perspective on the strengths and weaknesses of the internship experience. With such a small sample size, the survey was not framed into a theoretical model as in [4-8] and the questions used have not been validated. The survey contained 36, 5-point likert scale (from strongly agree to strongly disagree) questions which were separated into 3 categories: A) 15 questions about their learning experience (research skills, self-regulatory and lifelong learning, and belonging); B) 14 questions related to the training and learning environment; and C) 7 questions related to their aspirational elements after the internship. The survey then concluded with 5 reflective questions. (The survey is available for sharing and can be modified by other professors to fit their survey objectives. Please contact the lead author.)

The Vanier College Research Ethics Board approved all procedures related to this research study. The survey was sent to all students in fall 2022 and was voluntary. All students provided consent to participate in this research study.

3. SURVEY RESULTS AND DISCUSSION

Figure 1 shows the student responses to a subset of questions about their learning experience, such as gaining and/or improving research skills (questions 2-9) that will be useful for their future research work, self-regulatory and lifelong learning (questions 1, 12-13), and their sense of belonging to the research group and university (questions 10-11). The student responses to a subset of questions related to the training and learning environment (questions 16-25) is displayed in Figure 2. Last, Figure 3 presents the student responses to a subset of questions related to their aspirational elements after the internship (questions 30-34).

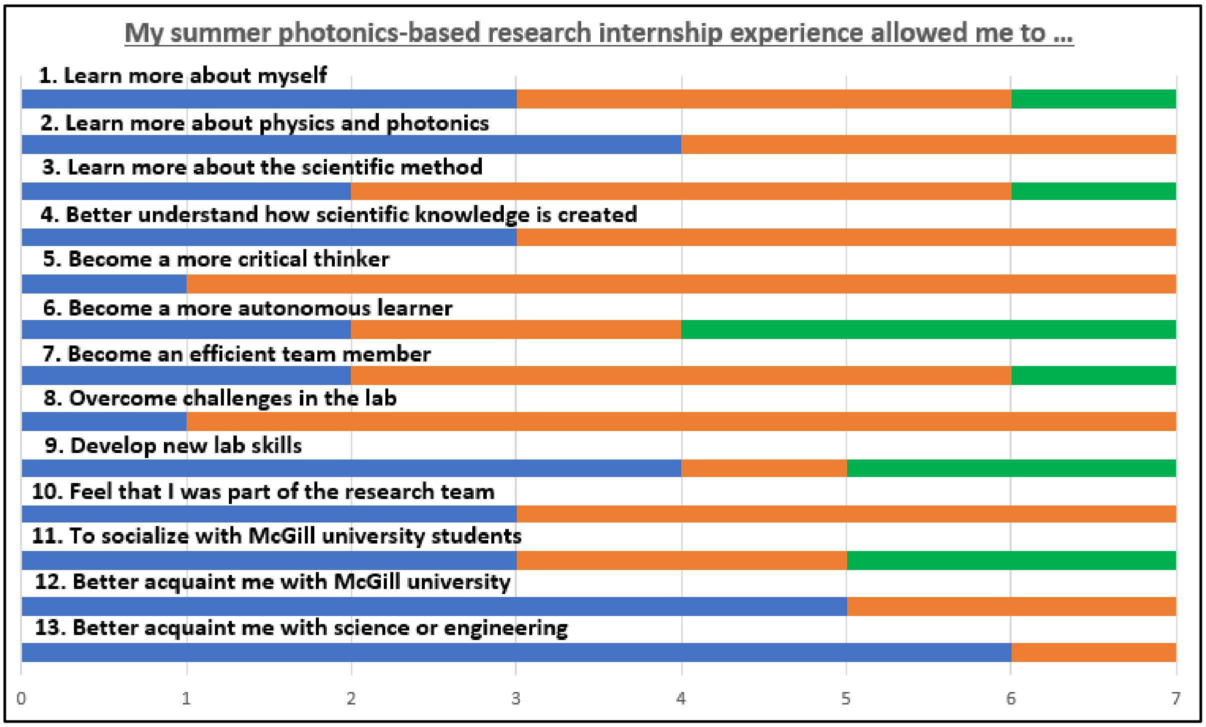

Figure 1: Student responses (student count) to questions about the students' learning experience.
Blue = strongly agree, orange = agree, green = neither agree or disagree.

The survey results for questions 2-9 show that most of the students agree or strongly agree that their internship experience allowed them to gain/improve their research skills. Question 6 had the least agreement – this is no surprise considering the college students' limited academic and research experience, the nature of the experimental work and the duration of the internship. Some students had experiences that were less active in the lab and/or worked on simpler experimental setups – these students may have not developed new lab skills (question 9).

All students agree or strongly agree that their internship experience allowed them to better acquaint themselves with McGill University, and science or engineering (questions 12-13) This is consistent with questions 30-31, that is, their internship experience helped inform their decision to study science or engineering at McGill University.

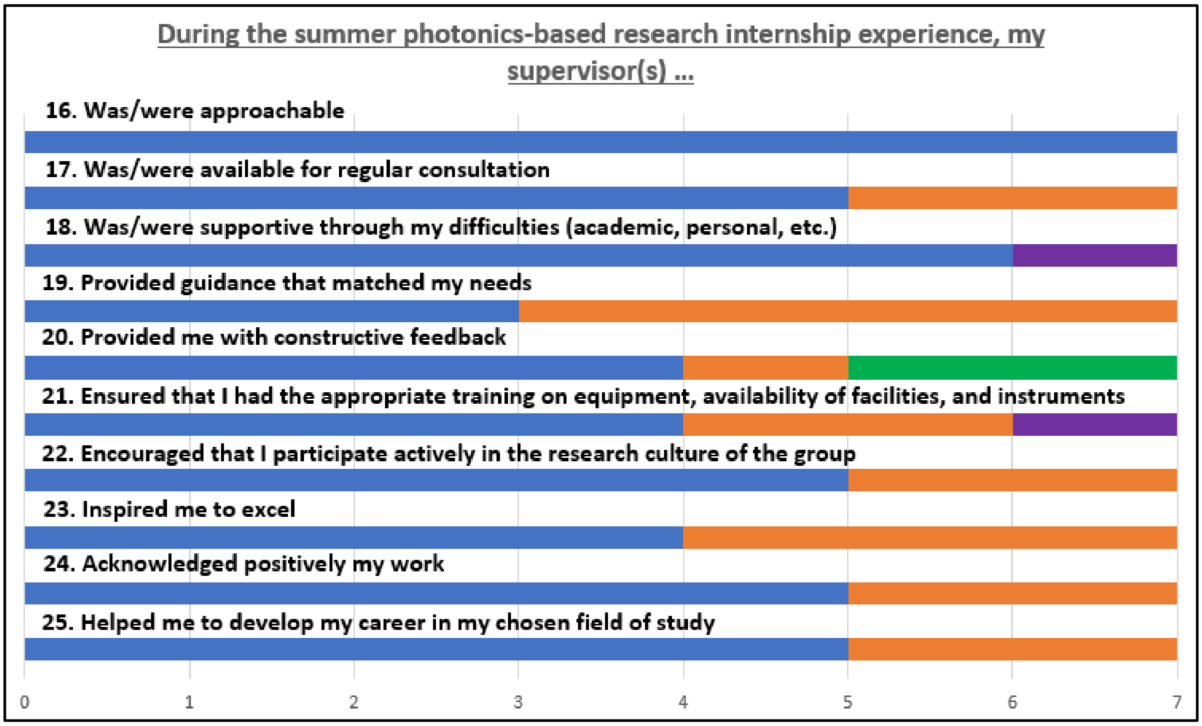

Figure 2: Student responses (student count) to questions about the students' training and learning environment. Blue = strongly agree, orange = agree, green = neither agree or disagree, purple = not applicable.

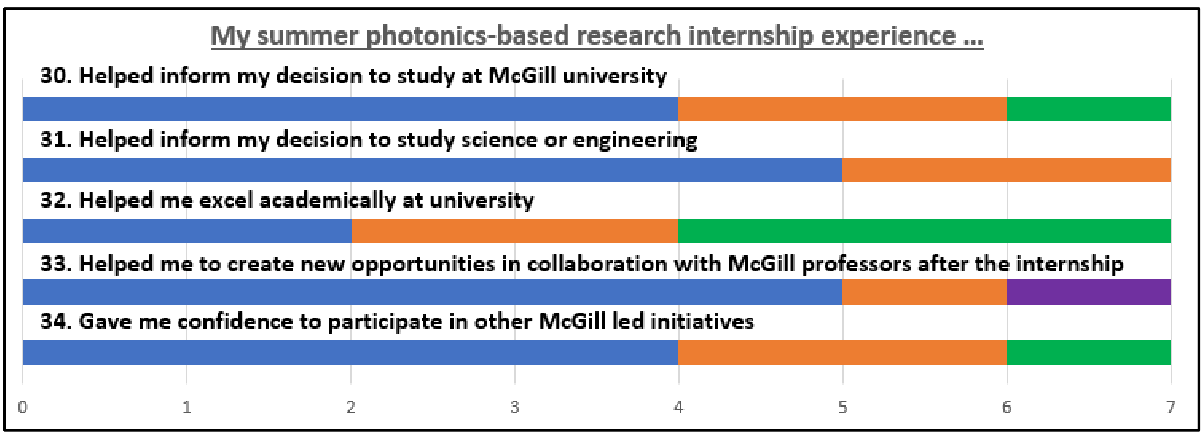

Figure 3: Student responses (student count) to questions about the students' aspirational elements after the internship. Blue = strongly agree, orange = agree, green = neither agree or disagree, purple = not applicable.

As mentioned in section 2, a teamwork approach to the internship was taken. The college students worked closely with the college professor and/or a (post)graduate student(s). Depending on the summer, the team also consisted of McGill undergraduate students and/or visiting professors. The (post)graduate student(s) acted as mentors to the lesser experienced students in the team. Questions 16-25 relate to the college students' training and learning environment. The supervisor(s) in question refer to the college professor, the university professor and/or the (post)graduate student(s). The survey results are indicative that the students were exposed to a positive training and learning environment. We can relate question 22 to questions 10-11. The students were encouraged to participate actively in the research culture of the group (e.g., attend group meetings) and this could have helped make them feel that they were part of the research team. However, depending on the composition of the research team, not all college students had equal opportunity to socialize with many McGill university students.

Even though none of the students continued in photonics, all students agree or strongly agree that their supervisor(s) helped them to develop their career in their chosen field of study (question 25). The students pursued other engineering fields or physics, and view their research experience in photonics as positive. Referring to questions 33-34, most students agree or strongly agree that their internship experience helped create new opportunities in collaboration with McGill professors (e.g., 4 of the students became teaching assistants or pedagogical research assistants with the university professor, 2 others continued with graduate studies with other research groups), and gave them confidence to participate in other McGill initiatives (e.g., student led engineering teams).

The reflective questions included in the survey helps us gain a better student perspective on the strengths and weaknesses of the internship. To the question, "Did the summer photonics-based research internship experience meet your over all expectations that you set prior starting the internship?", even though each student had varying levels of expectations, 6 students answered yes. When asked, "If you could go back in time, would you pursue the same internship?", all students answered yes.

When questioned about the aspects that they enjoyed most and/or felt were the most rewarding, the answers include: learning about photonics, telecommunications, the research process, and applying theory to solve problems; observing/participating in experiments and asking questions; feeling that they are part of the project, belonging to the group and attending group meetings; presenting their work at conferences and to newer college students.

Regarding aspects that the supervisors could improve to make the experience more positive, students answered the following: having more opportunities for "hands-on" work, being challenged more (with the experiments and analysis), providing a clear plan of what is expected from students (what needs to be learned and then completed), having more opportunities to meet undergraduate students, and being provided with more mentorship.

The last question was, "What advice would you share with a current college student wanting to participate in a similar internship?" Advice given includes: even if photonics may not interest you most, do engage with a research experience; do not worry if you feel inadequate at first and/or find the content difficult – go for it, be curious, and ask lots of questions; ask your supervisors if there are materials/content that you can read/watch before starting the internship (e.g., learning about specific photonics content, learning how to use specific software, etc.).

Given the complexity of some projects, limitations to equipment availability (some test-and-measurement instruments are shared among different research teams), project deadlines and the short duration of the internships, it is difficult to implement all proposed improvements. However, there are some aspects that can be modified or improved. Student goals and expectations regarding the internship should be discussed before committing to the internship. The internship duration will play a big role on determining what student goals can be achieved. For an experience that includes more experimentation (or more "hands-on" work), the internship should probably last more than 5 weeks. This would allow time for training on specific equipment and time to conduct more experiments. For an experience that includes more of an assisting role, for example, analyzing data and/or plotting graphs in parallel with the grad student performing experiments, then the internship could last 2-4 weeks but would require training for specific software.

Students who shared a more rewarding experience and shared less improvements did partake in a more active role within the research. In these cases, the project goals were clear, the experimental setups were simpler (less equipment was needed, therefore there was less sharing with other researchers), and the students had an explicit responsibility. Examples include being responsible for preparing software scripts to control various filter designs, and/or automate measurements. It is important that future college students should have a clear role within a project. We believe that having "ownership" on a specific part of the project contributes to their sense of belonging within the group.

Similar to the idea of "ownership," we believe that students should have a research artefact to share at the end of their internship. Akin to its use in active learning pedagogies (e.g., see [9]), the artefact should evolve during the internship, just like the software scripts to control various filter designs mentioned earlier – these scripts evolved during the summer and were then used again following summers. Many of our students did produce artefacts that were shared. In addition to software scripts, many of the students did prepare presentations that were presented to new cohorts of the college Waves and Modern Physics course. Some helped prepare posters that were presented in college research conferences and some contributed articles for the college science journal. We believe that it is important that students have a collection of artefacts and that the mentors can help with its evolution. In addition to the shared artefacts described above, students should be encouraged to document their learning and research findings (e.g., log books) and reflect on their own learning.

Last, since the college students will be enrolling into university, it is important they have opportunities to meet university undergraduate students. Since undergraduate students are often hired for summer research internships, it would be ideal to match college and undergraduate students in the same research group. If this is not possible, then supervisor(s) should help find ways for the college students to interact with undergraduate students on campus.

4. CONCLUSIONS

We have presented survey results and reflections on the impact of paid summer photonics research internships for college science students. Pertaining to their learning experience, the students agree or strongly agree that their internship experience allowed them to gain/improve their research skills, felt a sense of belonging within the research group and allowed them to better acquaint themselves with McGill University, and science or engineering – these students subsequently enrolled in science or engineering at McGill University. The supervisor(s) provided a positive training and learning environment. To improve future internships, it is suggested that 1) student goals and expectations regarding the internship are aligned with the internship duration and project complexity, 2) students should have an explicit responsibility within the project, 3) students should produce artefacts that evolve over the project duration, and 4) in addition to working with professors and (post)graduate student(s), college students should have opportunities to interact with university undergraduate students.

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