**Benefits of Biomedical Engineering Internships Conducted in Biomedical Engineering Departments in Hospitals**

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*Abstract* **– Biomedical engineering internships for undergraduate students are difficult to find as there are not many that exist. The University of Ottawa Heart Institute together with the Leacross Foundation has offered internship opportunities to female students in Biomedical Engineering programs since 2010. This paper discusses the benefits on hiring biomedical engineering interns for the Biomedical Engineering department as well as the intern’s development.**

**1.0 Biomedical Engineering Internships at Hospitals**

Engineering is widely regarded as a field that requires experience and practical work to develop meaningful and useful skills. In fields other than biomedical and clinical engineering, it is common for new engineering graduates to enter their respective field in a junior engineering position that provides exposure to the environment in which they learn and gradually take on more responsibility. In biomedical and clinical engineering these opportunities are very limited compared to other fields. Not only does this make it challenging for biomedical engineers to gain relevant experience, but they also fail to gain an understanding of the hospital environment. This experience is critical for them to understand how the environment, and staff interact with medical devices and processes, both of which they could design and develop as they grow in their biomedical engineering careers.

One internship program that does exist takes place at the University of Ottawa Heart Institute (UOHI) in the Biomedical Engineering (BME) department funded by the Leacross Foundation. The Leacross biomedical engineering internship was specifically created for women in engineering programs to gain hands on experience [1]. The BME Department at the UOHI, in partnership with the Leacross foundation, offers training internships for undergraduate and graduate biomedical engineers, and biomedical technicians and technologists. The internship provides trainees with the opportunity to train and advance their engineering skills in the Heart Institute’s dynamic medical environment. The Leacross internship is a 4-month program in the BME department where interns shadow technologists, clinicians, and work on a project relevant to the medical field. During the first two months, interns predominantly work alongside technologists, learning how to follow preventative and corrective maintenance procedures, and learning about the hospital and cardiac care. Each trainee is assigned to a BME team (patient care, critical care, diagnostic imaging) each week. During the second half, the interns work predominantly on a clinical engineering project and continue learning with the BME technologists. Interns are also provided with shadowing opportunities to understand different discipline’s roles in the hospital and how they interact with biomedical engineering technology [2].

The goal of the internship is to create an immersive experience exposing trainees to clinical engineering and biomedical devices and their function in the hospital environment. Simultaneously, students complete a project that benefits the hospital and the department long term. This internship allows students to gain insight into career possibilities in the biomedical field, something often missing from university education. The Leacross/UOHI internship has fostered experiences for almost 20 women studying engineering, giving them experience and knowledge that has been carried forward into their careers [1]. These interns have gone into careers in hospital clinical engineering, EEG systems device design, and artificial intelligence medical research.

**2.0 Benefits to Students and the Department**

To determine the advantages of the program to engineering students and the department, five interviews were conducted with past participants from 2010, 2015, 2017, and 2019. They were asked about their internship and the impact it had on their career. Interviews were also completed with the Leacross foundation donor and a senior leader at the UOHI involved in the development of the program.

*2.1 Benefits to Engineering Intern*

*A. Engineering Projects*

Clinical engineering projects given to the interns expose them to real-world problems in clinical engineering. Examples include:

* Computerized Maintenance Management System (CMMS) module development for auditing purchases and device tracking
* Assessment of organ cooling effectiveness and cooling distribution in transport coolers
* Creating compatibility between ventilators and metabolic measurement instruments to allow for analysis of energy expenditure through exhaled air
* Continuous Cardiac Output (CCO) monitor market research
* Inventory of research institute equipment for inclusion in a new Research Equipment Management Program managed by BME [2]

Through these projects, each of the interns had the chance to collaborate with clinical teams and learn the importance of record keeping for medical device management. Interns noted they learned how different stakeholders require different lines of communication and have different priorities. They noted the importance of keeping an open line of communication between every stakeholder to manage expectations. This invaluable knowledge cannot be acquired from university education.

*B. Shadowing Technologists and Clinicians*

Engineering interns work alongside biomedical technologists as well as shadow clinical teams throughout the teaching hospital. The hands-on experience taking equipment apart while performing preventative and corrective maintenance gave students confidence using tools. Women in engineering often doubt their skills with hands-on work. The opportunity to troubleshoot equipment, with reassurance from technologists on students’ capabilities with tools, provided them with confidence to take forward into their university labs. Interns noted the acquired knowledge in troubleshooting and repairing devices instilled confidence in their capabilities in handling tools, an opportunity not often available in university courses. Two interns agreed the hands-on experience troubleshooting medical devices gave them a broad understanding of medical devices in a hospital setting. They acknowledged the opportunity to sit down with technologists who understand the biomedical devices is an invaluable part of the internship that gave them knowledge on equipment maintenance that they use currently in their career. Senior leadership involved in the development of the program noted the importance for future engineers to have exposure working with technologists in the department to develop leadership skills by learning about the processes and customary practices of their work.

Shadowing clinicians is also a significant part of the Leacross/UOHI internship. This includes shadowing perfusionists, respiratory therapists, cardiologists, sonographers, and other disciplines. As one intern said, this gives insight into various medical careers and their roles which is not covered in classes or other internships. This is a critical component of the internship that exposes interns to how medical devices are used throughout the hospital along with how they are managed. This contextualization is essential for any medical device design work, healthcare project management or regulatory roles.

*C. Overall Benefits to the Intern*

Out of the five interns interviewed, all five agreed they gained something from the internship that they could not get from their university education. One intern noted the software development work they did on the device management system led them to go into a masters (and subsequently a PhD) working on artificial intelligence in medical applications. Another intern acknowledged shadowing MRI technologists guided them to study medical imaging (specifically MRIs) in their master’s program. Three of the interns currently work in clinical engineering in hospitals. They all agreed that the internship helped shape the career paths they are on today.

During the interview, past interns were asked if they think every biomedical engineering undergraduate student should experience this type of internship. All five interns agreed it is an important opportunity however it may present a potential burden to the healthcare system to train biomedical engineers. This is discussed further in the following section (section 2.2).

*2.2 Benefits to Biomedical Engineering Department and Hospital*

Having a student intern in a BME department yields short- and long-term benefits for the department and the hospital they reside in. The department has found that while students can help with technical work, more importantly it gives the technologists new opportunities and viewpoints. Younger staff gain confidence sharing their knowledge and improve their communication skills. To teach the students, the staff think about biomedical and clinical information more deeply, providing better understanding of concepts. Students bring a different lens to problems and processes encouraging BME staff to critically think about their practices. Additionally, new knowledge is shared with staff. Most recently at UOHI, best practices on using and maintaining a 3D printer. And finally, the students bring enthusiasm and energy to the department. The projects students work on have long-term impact for the hospital. These projects are noted in section 2.1.A. One project in particular included work on tracking devices in a medical device management system. This work has been used as many as 5 years after that intern finished their term [3].

Despite the benefits listed above, it does take a significant amount of work and time to run a successful program. For students to have a successful learning opportunity, staff need to be committed to taking the time to train them on simple BME activities, introduce them to colleagues throughout the hospital and mentor them through their project. It can be a mutually beneficial program. However, clear understanding of roles and responsibilities must be laid out before the program. This includes the expectations for technologists to undertake and teach students and for the students to be willing to follow the leadership and instruction of hospital staff. Additionally, short and straightforward engineering projects must be available [3].

**3.0 Contextualization in the Clinical Engineering / Biomedical Engineering Field**

One substantial benefit of a biomedical engineering internship for undergraduate students taking place in a hospital is the contextualization of university course work. One supervisor at the UOHI noted they taught clinical engineering courses at a university and could see students leaving the university that had never had exposure to the hospital. University undergraduate degrees are very theoretical and having hands-on work in a hospital to see how things are deployed is something that is missing from undergraduate programs. This supervisor also noted that they have been asked to consult on various academic graduate students’ projects and it has been apparent to them that the environment at a hospital is very different to the environment in a lab. Their knowledge of the clinical environment feeds into the success of products, processes, and regulations they may develop in the future.

Some studies have examined the risk of not considering human factors into medical device design. A study done on the effect of medical device user errors showed evidence that it is a significant factor in the deaths and injuries of thousands of patients. This article notes poor consideration of human factors design is a substantial contribution to the cause of these medical device user errors [4]. By seeing how medical staff interact with equipment, environment and culture they are placed in, the interns will be better prepared to take human factors into consideration in their future careers. As noted by graduates of the Leacross/UOHI program, the opportunity provides them with a broad understanding of how medical devices are used in hospitals, the various roles in the hospital and an understanding of the processes and work required to make medical devices safe and effective in the clinical environment. As noted by graduates of the Leacross/UOHI program interns, the opportunity provides them with a broad understanding of how medical devices are used in hospitals, the various roles in the hospital and an understanding of the processes and work required to make medical devices safe and effective in the clinical environment.

**4.0 Conclusion**

Biomedical and clinical engineering fields suffer from the lack of practical internships available for undergraduate students. This results in a lack of contextualization and hands on skills that can be gained from biomedical engineering internships taking place in hospitals. As a part of the Leacross Biomedical Engineering Internship at the UOHI, women have been able to learn skills that they could not gather from their education at university. This internship has pushed many of them onto their career paths and provided them with background knowledge and experience that they use in their careers to this day. More internships like the Leacross Foundation biomedical engineering internship taking place at the UOHI should be adopted, when possible, for the development of the BME department, the future engineer, and the biomedical engineering industry as a whole.

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# **6.0** **References**

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