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Tsinghua-Johns Hopkins Joint Center for Biomedical Engineering Research: Scientific and Cultural Exchange in Undergraduate Engineering

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Abstract—**A model for an international undergraduate biomedical engineering research exchange program is outlined. In 2008, the Johns Hopkins University in collaboration with Tsinghua University in Beijing, China established the Tsinghua-Johns Hopkins Joint Center for Biomedical Engineering Research. Undergraduate biomedical engineering students from both universities are offered the opportunity to participate in research at the overseas institution. Programs such as these will not only provide research experiences for undergraduates but valuable cultural exchange and enrichment as well. Currently, strict course scheduling and rigorous curricula in most biomedical engineering programs may present obstacles for students to partake in study abroad opportunities. Universities are encouraged to harbor abroad opportunities for undergraduate engineering students, for which this particular program can serve as a model.**

I. Introduction

A study abroad experience is often a major highlight in an undergraduate student's education. Taking a semester or year during college to study in a foreign country- completely immersed in a new culture, routinely speaking a newly learned language, dealing with and overcoming the challenges of adjusting to a new environment- can enhance a student's education and maturity, and give them broader perspectives of the world [1]. It is no wonder that study abroad is often looked favorably upon by both graduate and medical schools.

However, engineering students, in particular those majoring in biomedical engineering (BME) or bioengineering programs, are severely under-represented amongst the study abroad student population due to their intensive curricula and heavy course loads. In 2003-2004 academic year, roughly 191,300 students in the United States participated in study abroad. Of those, a mere 2.9% were engineering majors [2]. Even at The Johns Hopkins University (JHU), this under-representation is well-pronounced with a diminutive study abroad rate amongst undergraduate engineering students.

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The emerging trend in engineering education is an emphasis on a well-rounded curriculum comprising of technical subjects as well as increasing requirements in the humanities [3].

At JHU, all engineering majors are required to take 18 credits of humanities, and at least two writing intensive courses. The purpose of such a requirement is to broaden students' knowledge and critical thinking skills. The manner of thought, analysis, and communication skills exercised in these courses can be applied to many real-world situations, both in the scientific and non-scientific disciplines. The Accreditation Board for Engineering and Technology (ABET), the recognized accreditor of university engineering programs nationwide, states in its criterion that students in a successful engineering program should receive a "broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" [4]. The value of non-technical studies cannot be underscored enough for engineering students today.

Study abroad presents a great opportunity for engineering students to delve into the realm of humanities studies and gain beneficial experiences. Unfortunately, there exist a handful of challenges facing engineering students which must be surmounted if the disparity in study abroad participation is to be reduced [1].

II. Present Challenges

Engineering students are faced with an extensive number of required courses, which often have to be taken sequentially. For core technical subjects, there is a high degree of specific knowledge required. Unless a student is fortunate enough to study overseas in an engineering program approved by the home institution, taking a year "off" to study abroad may result in a major delay in the student's completion of his or her undergraduate education.

For most students, particularly those without a plethora of Advanced Placement or International Baccalaureate credits accrued in high school, taking a semester or year off to study abroad would entail prolonging college by an extra year. This situation is undesirable to many students and families for financial reasons and it postpones achieving career-oriented goals such as finding a job or attending graduate school. Furthermore, a vast majority of study abroad programs are, not surprisingly, focused on the language and culture of the foreign country. While surely interesting and enriching, these topics often do not pique the interest of many engineering students whose passions lay in the scientific disciplines.

However, many engineering students do take summertime opportunities to participate in laboratory research. Research offers valuable educational benefits, enhanced knowledge in a field of interest, and preparation for graduate school or a career. Then why not combine research with an abroad experience? Engineering students are not hesitant to take up summer research opportunities. If they can see that research in their field of interest can be done at an overseas institution, then perhaps this would be an effective way of providing an abroad experience for engineering students. However, there is a general lack of institutionally established abroad research opportunities for undergraduate engineering students.

III. The Research Exchange Program

The Johns Hopkins University (Baltimore, MD, USA) and Tsinghua University (Beijing, China) Departments of Biomedical Engineering have taken pioneering steps to address this relatively vacant niche in engineering educational opportunities. Through a joint effort, a unique summer research exchange program for undergraduate biomedical engineering (BME) students was created in 2008. In the summer of 2010, four JHU undergraduates participated in this exchange program: Nuala del Piccolo (sophomore), Bin Yang (junior), Nisha Iyer (junior), and Andrew Wisneski (junior). In the past three years, 13 undergraduates from JHU and 10 undergraduates from Tsinghua University have participated in this exchange program which is highly sought after by BME undergraduates at both universities.

Fig. 1. A student helps with a brain-computer interface experiment at Tsinghua University in the summer of 2010.

The Tsinghua-JHU summer research exchange program presents a solution to the challenge of study abroad for engineers and offers numerous benefits found in study abroad programs.

1) Scheduling: Since this is a summer exchange program, there would be no interference with regular course work and furthermore, no delays in graduation date.
2) Financial: Housing at the overseas institution is covered by the program and a living expense stipend awarded to students.
3) Research: Engineering students are willing to engage in research, as it is directly relevant to career and personal interests. Tsinghua University has many new and sophisticated laboratories spanning a diverse array of BME fields.
4) Location: Beijing, China has emerged as a cultural center of the world and is very accommodating to foreigners. Historical sites and the vibrant Chinese culture allow students to have an enriching, educational experience both within and outside of the laboratory.
5) Personal Development: In addition to knowledge acquired of a particular research topic, students working in a new environment and culture will have to develop team work, open-mindedness, and communication skills. These attributes would be useful for any career field.

IV. Program Administration

Shortly after the start of the spring semester, multiple announcements are made to BME students in course lectures and through emails announcing this summer research exchange program. Early notification of students is crucial. It allows students to decide whether this program is an opportunity they would want to pursue, and sufficient time needs to be allotted for the accepted students to obtain travel visas, schedule travel plans, and allow the host research laboratory to prepare for the arrival of the exchange student.

Students applying to the program are required to submit a resume, a transcript, and a cover letter expressing their reasons for interest in the Tsinghua-JHU summer research exchange program, listing at least two potential laboratories of interest at the overseas university. By browsing the university BME department website, students can find laboratory projects that would be pertinent to their own research interests. The final selection of the students is made by a faculty committee which takes into consideration the student's academic record, research interests, and character.

After students are notified of their selection for the program, they are required to secure a position in one of their laboratories of interest. Through email, a "Letter of Invitation" is provided to the student by the principal investigator of the host laboratory. The "Letter of Invitation" serves as official documentation for the student research position; for students visiting China, it is used in obtaining a "Class F" or business visa.

The principal investigator arranges for a graduate student to serve as a mentor to the visiting student and help orient him or her to the research laboratory, campus, and foreign city. Arriving in a new country and university can present a difficult and confusing situation; therefore a good graduate student mentor is an essential part to the success of this program.

Housing fees are covered by the Tsinghua-JHU summer exchange program, and a living allowance is awarded to students to cover daily expenses. Upon completion of their stay, students submit a report detailing their contributions to a research project, what they learned, and an evaluation of the overall experience.

V. Student Testimony

The following are excerpts from the students' reports about their experiences and thoughts of the program. It is apparent that the Tsinghua-JHU exchange offers a fulfilling research opportunity and cultural enrichment.

A. Andrew Wisneski (JHU Class of 2011)

In Professor Bo Hong's Neural Engineering Laboratory, Andrew studied and helped develop new algorithms for Brain-Computer Interface. The goal of this technology is to allow paralyzed patients to communicate their thoughts to others with the aid of a computer. Modulations in the electroencephalogram were detected to choose the desired option presented on the computer screen. Andrew remarks, "this program was invaluable to my engineering education and to my entire college education. Besides learning about a fascinating research subject that can benefit many patients, I was able to better appreciate the biomedical technology needs of China and how they differ from those in the United States."

B. Nuala del Piccolo (JHU Class of 2012)

In Professor Jing Liu's laboratory, Nuala researched bioheat transfer and nanoparticles. She performed experiments to characterize freezing properties of tissue in a cryogenic state and helped develop novel cancer treatments. Nuala was delighted to find that "working with Chinese students enabled me to learn about their daily life, society, and culture. I also enjoyed the fact that I was able, and encouraged, to visit the famous sites in Beijing where I learned more about Chinese history, architecture, and religion. This program really broadened my perspective of the world."

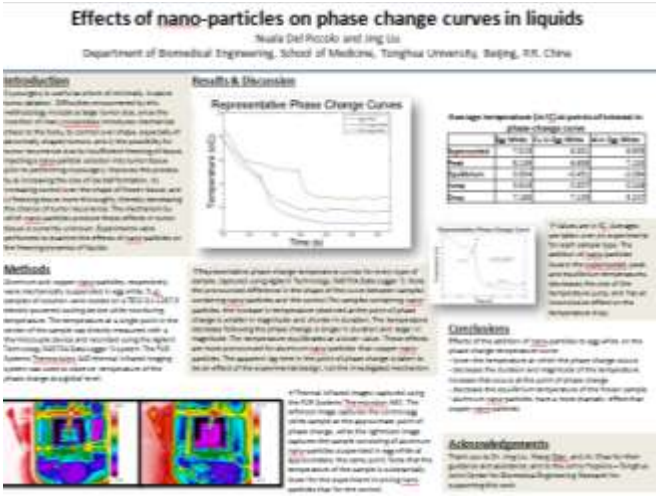

Fig. 2. A sample student poster resulting from summer research conducted at Tsinghua, later presented at an undergraduate BME research poster session in Fall 2010.

C. Jasper Chen (JHU Class of 2010)

In Dr. Fuzhai Cui's laboratory, Jasper studied the drug release dynamics of nano-particle microspheres. Jasper appreciated how the different culture influenced laboratory dynamics, observing a "different approach to research at Tsinghua. However, just as valuable as my experience inside the lab was my experience outside the lab. Beijing is a beautiful and exciting metropolis and I found the environment ideal for a university student."

D. Shen Li (Tsinghua, Class of 2010)

Shen worked in Dr. Xiaoqin Wang's auditory physiology laboratory at the Johns Hopkins Medical Institution. She comments, "After arriving in America, the challenge of independent living was exciting. I had to adjust to a new environment, including language, culture, customs and the way of thinking. The researchers and students I worked with were excellent. I learned much from them and better developed independent and critical thinking skills. I am very thankful to the Tsinghua-Johns Hopkins Joint Center for Biomedical Engineering Research for providing me such a precious opportunity. I wish for the communication and collaboration between the two schools to increase in the years to come."

VI. Positive Outcomes

Both Tsinghua and JHU receive benefits from this research exchange program. Benefits are conferred upon students and at the departmental level as well.

A. For Tsinghua and JHU students

Students from Tsinghua and JHU learn about and contribute to research projects pertinent to their interests, acquire new teamwork experiences, and receive cultural enrichment.

B. For JHU BME

A close-knit relationship between Tsinghua students and JHU is fostered. If Tsinghua students apply to JHU for graduate studies, JHU faculty has already had the opportunity to evaluate the strengths and interests of the Tsinghua students.

C. For Tsinghua BME

Tsinghua University can enhance its own undergraduate and graduate BME programs by consulting JHU's curriculum and faculty. The relationship with JHU allows for greater collaboration with research endeavors and facilitation of data exchange.

VII. Discussion

With the establishment of the Tsinghua-Johns Hopkins Joint Center for Biomedical Engineering Research comes the foundation for an excellent educational opportunity for BME students. This program is a viable solution to the shortage of relevant abroad experiences for engineering students.

The educational and cultural success of this program depends on students being able to contribute to a laboratory project by means of regular, direct personal interactions. Visiting students need opportunities to talk with and learn from the graduate students and professors in the host laboratory. Initially, this may be challenging due to language barriers, cultural differences, and unfamiliarity amongst the foreign and native students. However this is usually overcome after a short period of time, and a key objective of

this program is for the students to learn how to cope with the adjustment to a new environment and culture.

For instance, visiting students would be assigned to analyze recently acquired data using new Matlab functions, run experiments using a new protocol, or present the latest data at an upcoming laboratory meeting. These tasks often, and should, require collaboration with the graduate students in the lab. It is important that the host professor make an effort to arrange such tasks to be delegated regularly to the visiting students. Additionally, professors encourage graduate students to have discussions with the visiting student, highlighting the topics of their research and taking the time to answer questions.

The idea is that these encounters do not merely serve as research discussions, but that they also function as cross-cultural exchanges. A discussion between students about the research project may conclude with light-hearted remarks and a curious exchange of questions about the education, life, attitudes, and culture in the United States and China. A significant portion of the cultural enrichment from this program will come from the interactions and conversation in the laboratory.

The implications of a U.S.—China scientific exchange program have greater meaning in light of our world's future. One fifth of the world's population, about 1.3 billion people, lives in China. In accordance with the modern philosophy of engineering education, engineering students should be able to adopt global perspectives of how technology can impact society and the responsibilities therefore entailed of engineers [5]. Biomedical engineering students have to understand that their future research and technological endeavors should be able to improve health care and benefit mankind around the world. However, they must keep in mind certain socio-economic constraints when developing new technologies.

Biomedical engineering innovations designed to help the people of China, and in other developing nations, must be governed by the motto of "cost-effective, portable, and simple to use." Different types of socio-economic constraints on engineering innovations and practices need to be considered when being applied to different regions of the world. These engineering considerations are already being introduced to undergraduate BME students in Johns Hopkins medical device innovation courses such as Biomedical Engineering Design Team and Professor Nitish Thakor's "Design of Economic Health Care Technologies" and Biomedical Instrumentation courses.

It has been suggested that this exchange program be expanded to offer a sequel to the year-long Design Team course. Functional prototype medical devices could be brought to Tsinghua University and evaluated by medical centers in China. Similar to Johns Hopkins BME, Tsinghua BME maintains an extremely close relationship between the engineering and clinical fields. Foreign clinical feedback can highlight new perspectives, opportunities, and improvements for the design team projects. Students can learn how projects may need to be adapted to meet the requirements of a foreign clinical environment, and can gain exposure to the practice of health care in a different society and culture.

Biomedical engineers will always be involved in the development of medical technologies. Both Tsinghua and Johns Hopkins Universities are firmly united toward the advancement of medicine around the world; undergraduate engineering students should be able to appreciate this mission and ultimately, contribute to it. The Tsinghua-JHU research exchange program is a novel way to address this facet of engineering education and broaden students' perspectives about how engineering can impact people's lives.

VIII. Conclusion

Since its inception in 2008, the Tsinghua-JHU summer research exchange program has had a total of 23 participants: 13 from JHU, and 10 from Tsinghua. We hope this program will continue to blossom and accommodate increasing numbers of students each year as additional funding is procured. Universities are strongly encouraged to establish and promote abroad opportunities for engineers and should emphasize the benefits of such an experience.

Many of the problems that engineers will face in their careers will involve more than just science- but rather a combination of science, technology, economics, and culture. Engineering is now a global enterprise, and oftentimes, problems are solved on multi-national teams [6]. Engineers should be capable of tacking these global problems and BME students in particular should be driven to bring the benefits of medical science to people all over the world.

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