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A North American Consortium on Rehabilitation Engineering and Technology for the Individual

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A North American Consortium on Rehabilitation Engineering and Technology for the Individual

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Abstract

The availability and accessibility of appropriate rehabilitative healthcare, medical technology and treatment is an important national and international issue of particular relevance due to recent national healthcare reform initiatives. The focus of this project was to increase global competencies and awareness among biomedical engineers of the differing rehabilitative healthcare needs in North America via student exchange with consortium institutions in the U.S., Canada and Mexico. The aim was to increase understanding of alternative healthcare delivery systems with respect to technology and interaction with diverse client populations in a clinical setting and to enhance the development and technology transfer of new scientific tools and techniques, medical devices, and related biomedical research.

To date, more than 50 undergraduates have expressed interest in these programs, with over 30 students completing applications, and travel awards extended to 18 students (16 of whom opted to participate in study abroad experiences). Assessment tools included: a healthcare survey, two case study reports, global perspectives inventory documenting cultural differences, cultural comforts and the campus environment for culture and cultural tolerance, and interviews of the exchange participants and faculty research mentors by the external program evaluator.

INTRODUCTION

The North American Mobility Program provides travel awards to support undergraduate education via the establishment and implementation of exchange programs among Mexico, Canada, and the United States [1]. Projects are to encourage cooperation and exchange, increase knowledge of the languages, cultures, and respective institutions, increase the quality of human resources development, explore ways to prepare students to work throughout North America, and augment student mobility.

The availability and accessibility of appropriate rehabilitative healthcare, medical technology and treatment are important to an individual's short- and long-term health, quality of life, activity, and productivity. Related coverage, both federal and private, differs across North America. Resources with respect to medical technology innovation and device regulation also vary. The *focus* of this North American Mobility Program project was to increase awareness among biomedical engineers of the differing rehabilitative healthcare needs in North America via student exchange with consortium institutions in the U.S., Canada and Mexico (Table 1). The *aim* was to increase understanding of alternative healthcare systems and to enhance the development and technology transfer of new scientific tools and techniques, medical devices, and related biomedical/rehabilitation research.

HEALTHCARE SYSTEMS and HEALTHCARE TECHNOLOGY ASSESSMENT

Health Technology Assessment (HTA) is the evaluation of medical interventions or treatments (pharmaceuticals, devices, procedures) in terms of efficacy, accessibility and cost effectiveness. While

HTA is typically conducted nationally, it is more than simply the assessment of national health systems. Despite their geographic proximity, the U.S., Canada and Mexico have developed distinct healthcare and HTA systems [2]. These assessments reflect both similarities and differences in available health technology interventions, resources and access.

In the U.S., the healthcare system is both public and private. With public Medicaid and Medicare programs providing coverage for more than 60 million individuals (as of 2009), there is a continued need to balance public demand for advanced technologies with the reality of the expense for such treatments [3]. Minorities in the U.S. continue to face organizational, structural and clinical barriers within the healthcare system, diminishing their access to available technologies. These accessibility challenges, coupled with demographic changes, create a need for on-going HCA [4]. In 2010, the Affordable Care Act (ACA) or "Obamacare" was enacted with the goals of increasing the quality and affordability of health insurance, lowering the uninsured rate by expanding public and private insurance coverage, and reducing the costs of healthcare for individuals and the government. The impact the ACA on medical care has not yet been assessed, although the potential effects on the accessibility of medical care due to the ACA has been widely discussed [5, 6].

The healthcare system in Mexico is also public and private. More than 50% of Mexican healthcare expenditures, however, are out of pocket [7]. The primary barriers to healthcare are cost and access. Together with Mexico's National Institute of Public Health [8], the National Health Program is addressing inequalities in healthcare quality and accessibility.

In contrast to the U.S. and Mexico, the Canadian health care system is publicly financed system, administered by ten provincial and three territorial governments, covering approximately 70% of healthcare expenditures [9]. This universal healthcare system also supports collection of health data to monitor the healthcare system and inform evidence-based medicine. Healthcare coverage and formal HTA varies by province, facilitating consideration of local context [10].

While difficult to track and monitor, such local context and cultural background influence acceptance of new healthcare technologies. Perceived usefulness and ease of use must be considered [11]. As healthcare policies, funding initiatives, and technology change, it becomes increasingly important for biomedical engineering curricula to evolve so that students emerge from university prepared to understand and adapt to varying national funding and accessibility models, individual needs and cultural contexts, and international markets, companies and design / manufacturing / marketing / sales teams.

DEVELOPING GLOBAL COMPETENCE WITHIN BIOMEDICAL ENGINEERING EDUCATION

Increased parity within the field of engineering has removed advantages once held by top nations. In response, engineering educators and employers have identified global competence as a vital skill set for the 21st century, recognizing that the ability to collaborate *across* borders provides a competitive advantage [12]. This skill set, sometimes referred to as intercultural competence, is also vital *within* the borders of advanced countries whose populations are becoming increasingly more diverse [13]. Increased intercultural competence may help reduce disparities in healthcare accessibility experienced by racial and ethnic minorities in North America [4]. Specifically, graduates need to be able to "clearly communicate via multiple forums, develop innovative solutions within real world and changing constraints, and adapt and learn about an unfamiliar environment, translate that learning into an understanding of customer perspective" [14]. Additional attributes include: being mobile and flexible, being knowledgeable about other places in the world, accepting differences, and perceiving differences in terms of engineering cultures [12]. Furthermore, students need an "understanding of the societal, economic and environmental impacts of engineering decisions" [15].

To develop such skills, degree requirements may include: "proficiency in a second language, international course work, an immersive international experience which should be combined in a coherent program that ties the elements together and integrates them within the students' major" [16]. Study abroad is one means of integrating these elements into the student experience [17].

Recent research has investigated what students are and are not learning as a result of their experiences abroad. Varying degrees of cultural integration, program structures, and duration have sparked dialogue regarding the effectiveness of programs with respect to developing intercultural competence [18]. Several models to implement intentional programming before, during and after study abroad experiences to facilitate this learning outcome have emerged [19, 20], including specific experiential learning opportunities for engineering students [15, 21]. Study abroad students have consistently demonstrated growth with respect to cultural integration [22]. Many instruments have been developed to assess intercultural competence, such as the Global Perspectives Inventory [23]. Through a 69-question inventory, the GPI evaluates intercultural integration along three dimensions each with two sub-scales: cognitive (knowing and knowledge), intrapersonal (identity and affect) and interpersonal (social responsibility and social interactions). Student growth can be measured utilizing a pre- and post-test model to assess student progress with respect to global competency as it relates to educational experiences. The GPI can also be used to direct programmatic changes in structure or curricula [23]. Alternative assessment instruments to directly measure of students' intercultural skills are also under development by engineering educators [24].

METHODS

Consortium institutions with historically strong biomedical engineering programs in the U.S., Canada and Mexico were identified. Key faculty with rehabilitation engineering research and teaching expertise were invited to participate and assist in the development, promotion and assessment of a unique exchange program for biomedical engineering upperclassmen. With the support of the North American Mobility Program, a North American Consortium on Rehabilitation Engineering and Technology for the Individual (NARETI) was initiated in 2010. The primary *educational objectives* of this program were: (1) to increase awareness of healthcare systems for rehabilitation with particular emphasis on the economics, device-related regulatory structure and individual privacy laws, (2) to increase awareness of the products and services available for rehabilitation with particular emphasis on their training, delivery, repair and technical support, and (3) to increase sensitivity to individual patients, doctors, researchers or others contributing to rehabilitative healthcare.

Documentation: Representatives from each of the consortium institutions (Table 1) met on two occasions to draft the memorandum of understanding (MOU). This MOU documented the tuition waiver (tuition to be paid at the respective home institution), student fees (travel, visa processing fees, room and board, books, and additional university fees), travel awards, refund policy, transfer credit evaluation and award procedure, recruitment process, admission standards, screening and selection of exchange applicants, number of exchange students, student pre-departure preparation, housing, and host institution orientation. Documentation related to human subjects "testing" was also submitted to the various Institutional Review Boards or equivalents to support dissemination of program details and aggregate student assessment data.

Curriculum Opportunities: Existing and potential new curriculum options at each partner institution were reviewed by NARETI faculty in concert with the program aim and educational objectives. Potential curriculum options included: capstone design projects, technical electives, rehabilitation engineering service projects, biomedical research experiences, medical device internships and clinical rotations, and cultural and language study appropriate for junior and senior biomedical engineering students. These curriculum options were shared with all partner institutions; program faculty then identified

Table 1: Partner institutions.

Partner Institution	*Country*	*Type*	*#Total Students*	*#Eng Students*	*#Biom Students*
Marquette University	U.S.	Private	11,800	1,400	380
University of Illinois at Chicago	U.S.	Public	26,200	3,100	340
University of Calgary	Canada	Public	31,320	3,240	125
University of Toronto	Canada	Public	73,785	7,208	254
University of Guadalajara	Mexico	Public	221,656	11,917	333
Tecnológico De Monterrey	Mexico	Private			
Chihuahua campus			2,550	1,450	129
Guadalajara campus			5,237	2,400	114

opportunities consistent with degree requirements of their respective home institutions, initiating formal institutional review for potential transfer credit. These details, as well as contact information for program liaisons at each institution (a staff person in the respective international office and a faculty member in biomedical engineering), were posted on a common website with links to websites for each of the consortium institutions.

Student Recruitment: Program information for the NARETI program was disseminated to potential engineering student participants through the aforementioned website and promotional literature distributed by international office staff and engineering faculty. Information venues included study abroad information fairs, open house events, and emails and/or classroom visits to biomedical engineering sophomores and juniors. Interested students were encouraged to contact their international office or NARETI faculty representative for more information. Students then submitted a study abroad application, including potential coursework and research interests, to their home institution by the published application deadline.

Student Admission and Travel Award: International office representatives and program faculty reviewed submitted applications in terms of applicant quality and program exchange allocations. Program funding supported up to eight (two at each of the four institutions out of country) student exchanges per institution, 48 student exchanges total over the 5 year project duration. The international office at the home institution contacted the international office at the potential host institution(s), forwarding applications for those recommended for travel awards. The host institution determined final acceptance. Accepted students then worked with international office staff and program faculty at the host institution regarding travel logistics, curriculum options, and specific research/internship opportunities.

Program Assessment: Specific assessment tools were identified and an evaluation plan was developed to assess the program objectives, as mapped in Table 2. These assessment tools included: a healthcare awareness survey, two case study reports, the GPI [23], and interviews of the exchange participants and faculty research mentors by the program external evaluator (see Appendix). As per U.S. program guidelines, U.S. students studying in Mexico were also required to complete an oral Spanish language proficiency test [25] pre- and post-exchange to assess foreign language skill development. Staff members at the respective international offices collected student pre- and post-participation data (healthcare survey, GPI, language assessment) and tracked student numbers and curricular enrollment. The engineering faculty member distributed and scored the case study reports and scored the healthcare surveys.

RESULTS and DISCUSSION

More than 50 undergraduates expressed interest in the NARETI program, with over 30 students completing applications, and travel awards extended to 18 students (16 of whom opted to participate in study abroad experiences). These exchanges are summarized in Table 3. All students enrolled in various engineering technical electives, two students participated in a capstone design project, and all but two students conducted research in a faculty laboratory; no students participated in a rehabilitation engineering service project, medical device industry internship, or formal clinical rotation.

Twenty faculties participated in consortium site visits and/or hosted exchange students in their research laboratories; nearly 50 faculty welcomed consortium members into their laboratories during the consortium site visits. These consortium laboratory visits provided research internship opportunities for exchange students and may foster future faculty research collaboration. Two U.S. faculty members also taught classes in Mexico; one served as a visiting faculty member instructing students in rehabilitation robotics, another offered a biomaterials course using video-conferencing.

Assessments have been completed for 14 exchange participants; two students are currently studying abroad and their assessments have not yet been completed. These assessment results are summarized in Figures 1-2. Only two students have studied in Mexico thus far. Their pre-exchange Spanish language proficiency, as assessed with the standardized oral interview [25], was scored as intermediate-middle. The Spanish proficiency of one of these students improved to advanced-low post-exchange; the Spanish proficiency of the second student was unchanged post-exchange. While the assessment data are insufficient to investigate statistically significant differences pre- and post-exchange, the limited gains reflect the need for more intentional programmatic elements [18]. For example, to enhance language acquisition and development, future students might be required to enroll in a language course and/or participate in a homestay. Required pre-exchange readings might facilitate greater awareness and curiosity regarding home-/host-country healthcare systems. Formal, guided post-exchange reflection might also facilitate greater progress with respect to the program's educational objectives.

Table 2: Summary of NARETI program educational objectives and various assessment tools.

Assessment Tool	*Objective 1:* To increase awareness of healthcare systems for rehabilitation.	*Objective 2:* To increase awareness of rehabilitation products and services.	*Objective 3:* To increase sensitivity to rehabilitation individuals.
Healthcare Survey (pre/post)	questions concerning rehabilitation economics, regulatory environment, privacy issues	questions related to rehabilitation economics, regulatory environment	questions concerning privacy issues
Case Study Report 1: (week 3 of exchange)		examination of rehabilitation product/ service in host country	
Case Study Report 2: (week 14-16 of exchange)			interview of medical personnel/biomedical engineer in host country
GPI (pre/post, U.S. students only)			X
Interviews (post)	questions addressed rehabilitation individual, healthcare products	questions addressed rehabilitation product awareness	questions assessed student's transformation & growth in under-standing of rehabilitation individuals & products

***Objective 1*: To increase awareness of healthcare systems**

As shown by Figure 1, the pre- and post-participation healthcare survey responses did not reflect increased general awareness of healthcare systems. In fact, the post-exchange scores were often the same or slightly lower than the participants' pre-exchange scores. These participants were not enrolled in specific rehabilitation coursework and their rehabilitation research projects involved prototype designs that were not yet ready for healthcare adoption. These limitations hindered student learning with respect to this specific educational objective. However, post-participation interviews of the exchange applicants reflected qualitative increases in general understanding of rehabilitative technology specific to the student's research project. Exposure alone, particularly with respect to gains in cultural knowledge, does not facilitate competency development [12, 23]. Rather, intentional programmatic elements and guidance are needed to promote student learning [18, 21]. Future inclusion of pre-departure or while-abroad readings or products, regulations and repairs, may heighten

Table 3: Summary of student exchanges to date.

	Home	U.S.		Canada		Mexico	
Host		MU	UIC	Calgary	Toronto	U of Guad	ITESM
US	MU	NA	NA	0	0	1	1
	UIC	NA	NA	0	0	0	1
Canada	Calgary	3	1	NA	NA	1	1
	Toronto	2	1	NA	NA	1	1
Mexico	U of Guad	0	0	0	0	NA	NA
	ITESM	0	2	0	0	NA	NA

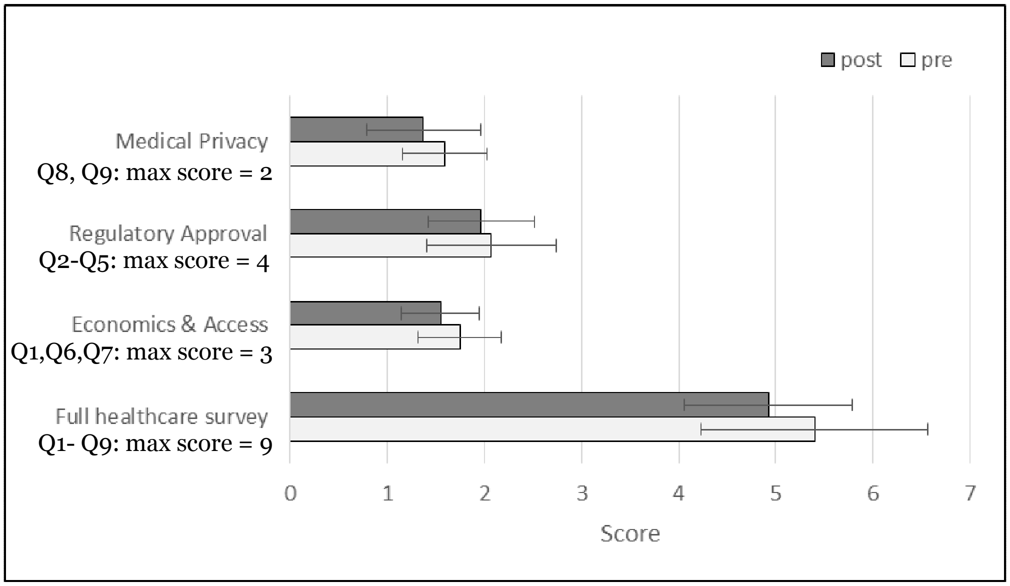

Figure 1: Healthcare survey scores and sub-scores pre- and post-exchange (N=14 students), see Appendix. Categories relate to the respective program educational objectives: 1) overall awareness of healthcare system (full survey), 2) awareness of rehabilitation products and services (regulatory approval, economics/access), and 3) sensitivity to the individual (medical privacy).

general rehabilitation and healthcare knowledge and home-country policies. Such preparation may also enhance student curiosity, a commonly discussed attitudinal dimension of intercultural competence [12], promoting greater exploration of such topics while abroad. Future foundational readings and assessments might also include comparison of the home- and host-countries' healthcare systems with that of the third North American healthcare system.

Objective 2: To increase awareness of rehabilitation products and services

This educational objective addresses knowledge of rehabilitative products and services in terms of training, delivery, repair and technical support. A subset of three questions from the aforementioned healthcare survey addressed issues of rehabilitation economics and access; four questions addressed issues related to regulatory approval of rehabilitation / medical devices. As indicated by Figure 1, these pre- and post-participation healthcare survey sub-scores do not reflect increased awareness of rehabilitation economics and access, although some improvement was noted by six of 14 students with respect to awareness of regulatory approval of medical devices. These marginal improvements may be attributed, at least in part, to the lack of enrollment in rehabilitation or medical device coursework and the preliminary nature of the design prototypes of their rehabilitation research projects.

This educational objective was also assessed via the second case study report (mean score: 4.1 ± 1.0 on a scale of 0: low to 6: high), an examination of a particular rehabilitation product or service available in the student's host country. Each student described a rehabilitation service or product, how the device achieves its therapeutic effect, and the pathway or major milestones by which the device entered, or will enter, the market place. In contrast to the healthcare surveys, the second case study reports demonstrated some knowledge, perhaps increased, of focused aspects of the healthcare systems, as well as evidence of knowledge of medical device-related regulatory issues.

During post-participation interviews conducted by the external evaluator, students cited several examples of increased awareness of training and delivery of rehabilitation products and services. These gains were based on their research experiences, discussions with their research mentors and graduate students, clinical rotation observations, and their case study reports. Students were particularly enthusiastic about what they had learned about rehabilitation products and services when they were able to witness patient interactions first-hand.

None of the current assessment tools demonstrated increased knowledge of the repair or technical support of these rehabilitative healthcare products and services. This again may be attributed to the lack of such content in the student's formal coursework and research experiences while abroad. As many consortium faculty have research laboratories in a hospital or on a hospital campus, future exchange might include a hospital tour inclusive of a visit to the biomedical engineering department so that exchange participants might observe and discuss requisite calibration, trouble-shooting, and related documentation of medical equipment. Inclusion of the aforementioned pre-departure or while-abroad foundation reading materials may also assist student learning with respect to this program educational objective.

***Objective 3*:** To increase sensitivity to rehabilitation individuals

Multiple assessment tools were also identified and administered to assess student progress with respect to sensitivity to individual patients, doctors, researchers or others contributing to rehabilitative healthcare. Student replies to the two healthcare survey questions addressing medical privacy issues (Figure 1) reflected strong awareness of privacy issues pre-participation, scores that remained largely unchanged after exchange participation. During interviews conducted by the external evaluator, participants expressed an understanding of the role of graduate students, research faculty and individual patients within the healthcare system and the patients' rehabilitative health. This understanding was strongly influenced by the student's biomedical research experience; research experiences are therefore recommended as a required curriculum component.

The first case study report (mean score, 4.7 ± 0.7 on a scale of 0: low to 6: high), completed during the first month of the exchange, summarized the student's interview of an individual in their host country (e.g. physician, nurse, patient, medical device entrepreneur or a biomedical engineer/researcher). The report described the person's biography, their role in the host nation's healthcare system and their most significant challenges or barriers to productivity. This exercise encouraged the students to ask questions with respect to healthcare and the role of the individual, and make comparisons between their host and home countries. This report served as an effective "ice-breaker" and introduction to the NARETI educational objectives. Pre-program foundational readings regarding national healthcare systems, related HTA and rehabilitation products might foster inclusion of more insightful interview questions and dialogue, further enhancing student learning with respect to the program educational objectives.

As a validated tool demonstrating student progress with respect to intercultural competence, the GPI was also included used to assess the effects of NARETI exchange on students' awareness of cultural differences, cultural comforts and the campus environment for culture and cultural tolerance – cultural differences that may affect medical device design, healthcare accessibility and/or acceptance of rehabilitation healthcare technology by an individual. Although only required for U.S. students, the inventory was also completed by NARETI students studying in the U.S. GPI data from 9 students are summarized in Figure 2, and reflect improvements in all areas, especially with respect to cognitive knowledge (cultural context in judging what is important to know and value), intrapersonal identity (awareness of one's unique identity, sense of purpose, and degree of acceptance of one's identity), and interpersonal social interaction (degree of engagement with others who are different from oneself and degree of cultural sensitivity in living in pluralistic settings).

Increases within one attribute of each dimension reflect students' enhanced ability to perceive differences within varying contexts and to identify vital values and knowledge to consider when working within different environments. Further, the improvements in intercultural integration attributes indicate that students better understand their own cultural identity, which may impact social interaction with those from different backgrounds. As students graduate and enter the diverse and global workplace, these improved intercultural integration skills may assist them in identifying key intercultural and interpersonal differences, increasing their sensitivity to diverse teams, clients, customers, and end-users/patients, and designing and marketing globally competitive medical devices.

One limitation of the GPI is that it *indirectly* assesses intercultural integration. Developing and utilizing a more *direct* assessment tool, ideally specific to health, disability and medical technology, may provide more accurate and insightful data [24]. The Association of American Colleges and Universities has developed rubrics for both global learning and intercultural knowledge and competence [26]. These rubrics might be incorporated into current and future written and/or oral assessment tools specific to health and disability to more directly assess student development with respect to this educational objective.

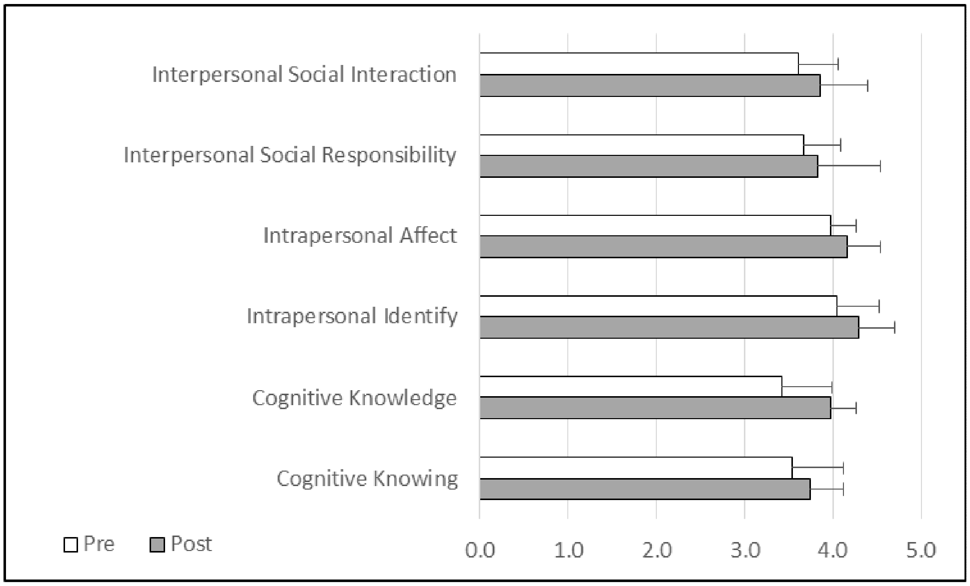

Figure 2: Global perspective inventory (GPI) intercultural competence dimensions and corresponding pre- and post-exchange scores for U.S. students and NARETI students studying in the U.S. (N = 9 students).

Summary: The NARETI program was designed to increase global competencies and awareness among biomedical engineering students regarding issues related to availability and accessibility of rehabilitative healthcare, medical technology and treatment within North America. No formal, validated assessment instruments or surveys currently exist, necessitating the development of new assessment tools. Despite the preliminary, rudimentary assessment instruments, the exchange of students between partner institutions in Mexico, Canada and the U.S. resulted in some positive gains in student development of global competency skills specific to healthcare and medical devices. Programmatic limitations, such as limited formal rehabilitation and medical device coursework and early stage research projects, likely contributed to the modest gains in the educational objectives. Qualitative data from post-experience interviews demonstrated that the program has been successful in achieving programmatic goals with respect to student growth in their rehabilitation healthcare awareness and perceived global competencies. Future program modifications including required foundational readings and guided, reflective post-exchange dialogue may enhance student-learning outcomes.

Program Limitations: Initial targets for student exchanges were eight per institution. None of the six partner institutions met these targets. Travel warnings in Mexico affected student exchange in Mexico, particularly with respect to the border state of Chihuahua. As such, student exchange was expanded from the ITESM-Chihuahua campus to include the ITESM-Guadalajara campus. While the alternative campus likely improved student safety, unlike the Chihuahua campus which offers coursework in English, coursework at ITESM-Guadalajara and the University of Guadalajara is offered in Spanish only. Many BME students in the U.S. and Canada do not have sufficient Spanish language skills to take coursework in Spanish. The University of Toronto noted that their students were interested in summer, rather than semester-long, exchange opportunities – an option that is not supported by the North American Mobility Program. The Canadian students, as well as many U.S. students, had less interest in North American exchange and preferred travel to another continent (e.g. Europe, Australia and Asia). The lack of Canadian mobility was also attributed, at least in part, to the primary research rather than academic appointments of the Canadian program faculty; inclusion of faculty with primary instructional appointments and undergraduate advising/mentoring responsibilities might increase Canadian student interest and participation. ITESM-Chihuahua personnel noted that the higher cost of living in Chicago and Toronto made exchanges to these institutions less attractive; recent government changes also tied up travel awards, making it more difficult for qualified exchange applicants to receive financial assistance from the Mexican government.

Lessons Learned: Given the recent challenges with increasing costs of medical care, creative public and private funding initiatives are needed to provide accessible, efficacious, quality healthcare. Biomedical engineering students can greatly benefit from enhanced awareness of both domestic and international healthcare systems. Educational programs incorporating foundational readings and relevant medical device research, clinical exposure, and regulatory experience address a timely need. However, more strategic planning is needed to develop specific programmatic educational objectives and provide complementary experiences and curriculum, guided dialogue and reflection, and targeted assessment tools.

While semester-long programs may promote more intensive study, summer programs might offer more flexible biomedical research, clinical and reflection opportunities that will be more attractive to students. The availability of travel awards (e.g. North American Mobility Program) or stipends (e.g. NSF's Research Experiences for Undergraduates) can further enhance student recruitment. Successful programs require several faculty advocates involved in program dissemination, student recruitment and research placement, and assessment of learning outcomes. The involvement of multiple faculty members will ensure that faculty transitions do not adversely affect program continuity.

Program Future: International office liaisons continue to meet annually at various international education conferences (e.g., National Association for Foreign Student Advisers, NAFSA, now Association of International Educators; European Association for International Education, EAIE). Several partner institutions expressed interest in sustaining the exchange beyond the life of the grant, perhaps through bilateral exchange partnerships inclusive of both semester-long and summer programs. Marquette University currently has a bilateral student exchange agreement with all 33 campuses in the ITESM system. Limited exchange continues under this agreement, especially with campuses located in lower travel risk cities as delineated in the U.S. State Travel Warning on México.

CONCLUSIONS

All interviewed student participants were very positive about their experience and stated that they would do so again and recommend the program to a friend. The experiences of current exchange students helped foster further exchange, both in North America and elsewhere, as these students shared their experiences with classmates. The presence of exchange students on the various host campuses enhanced program awareness and familiarity with the respective partner institutions. Many students, particularly those who participated in a rehabilitation device and/or clinical research experience, demonstrated increased awareness of healthcare systems, medical device regulatory requirements and development procedures, cultural sensitivity to patients, and the role of healthcare providers and researchers with respect to rehabilitative healthcare. Future efforts include identification and incorporation of additional programmatic elements such as pre-departure and while-abroad foundational readings and guided, reflective post-exchange dialogue to intentionally support program learning objectives, as well as identification of related rehabilitative healthcare opportunities after the funding period, including potential expansion beyond North America.

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APPENDIX

Healthcare Survey

These questions are intended to assess a student's understanding of the differences in the healthcare systems in the three countries from the perspective of an engineer working in the rehabilitation field. Specifically, students should understand the economics, privacy and regulatory considerations for each country. Each healthcare survey is graded on a scale of 1 (low) to 9 (high), with each question worth 1 point.

1) About how much is spent each year (*choose from: US$200, US$1000, US$2000, US$4000)* on healthcare per person in:
   a. Canada
   b. The United States
   c. Mexico

2) About how long (c*hoose from: 1, 6, 12, or 24 months)* does it take to get a typical medical device approved (from submission to approval) in:
   a. Canada
   b. The United States
   c. Mexico

3) About how many medical devices (*choose from: 10, 100, 1000, 5000)* are approved each year in:
   a. Canada
   b. The United States
   c. Mexico

4) Are most medical devices considered novel (*PMA*) or incremental (*510k*) in the American System?

5) What are the criteria (choose all that *apply: 1) safe and efficacious, 2) cost effectiveness, 3) approved elsewhere*) for approval of a medical device in:
   a. Canada
   b. The United States
   c. Mexico

6) About how many people (*choose from: 1%, 2%, 5%, 10% or 20% of the population)* do not have regular access to healthcare in:
   a. Canada
   b. The United States
   c. Mexico

7) For those without access, what is the most common barrier (*choose from: financial, distance to a health clinic, language)* to access to healthcare in:
   a. Canada
   b. The Unites States
   c. Mexico

8) Life insurance companies must keep all their clients data private *(yes or no)* in:
   a. Canada
   b. The United States
   c. Mexico

9) Information pertaining to healthcare billing or financial activity is publically available *(yes or no)* in:
   a. Canada
   b. The United States
   c. Mexico

Case Study Reports

To further evaluate the impact of the NARETI program on students, students were asked to write two essays (maximum of 1 page each) to assess their ability to articulate both their experience, and the depth of their experience.

- The first essay was a case study of an individual in their host country with whom they have worked. This individual might be a doctor, nurse, patient, medical device entrepreneur or a biomedical engineer/researcher. Students were asked to describe the person's biography, their role in the host nation's healthcare system and their most significant challenges or barriers to productivity.

- The second essay was an examination of a particular rehabilitation product or service available in their host country. Each student was expected to describe the service or product, how the device achieves its therapeutic effect and the pathway (major milestones) by which the device entered the market place or will enter the market place.

Each essay was graded by the faculty at the home institution as the students' demonstration of their understanding of the individual's role in the healthcare system and the role of engineering in the introduction and transfer of technology.

Grading Rubric: Each case study was graded on a scale of 1 (low) to 6 (high).

Case Study 1: Individual in their host country

1 pt naming the individual

1-2 pts accurate description of the role the individual plays in the healthcare system; an ideal answer would include the individual's contribution to the system as well as their points of dependency and interaction with aspects of the healthcare system.

1-2 pts description of the largest barrier or problem face for increasing their productivity; an ideal answer would include a description of the barrier, the reason the barrier is not overcome on a daily basis, and how the interviewee feels the barrier could be surmounted.

1 pt analysis of the individual's role in the healthcare system and the challenges they face.

Case Study 2: Product or service available in the host country

1 pt accurate description of the product or service.

1-4 pts description of the training the product requires, the delivery of the product, the repair of the product and the available technical support

1 pt analysis of the difference between their host country and their home country with respect to the selected product or service.

Student Interviews

To further evaluate the impact of the NARETI program on student participants, the program's external evaluator interviewed students post-exchange.

Sample questions:

1. Tell me about a situation where you were not sure of the outcome and you had to rely on strangers for help.
2. How do you feel when you really don't fit in? Tell me about a time when you really didn't fit in.
3. Describe a time when you needed to find a completely new way of solving a problem.
4. How do you handle failure? Give me an example of a time when something you tried to accomplish failed.
5. Tell me about someone you know (e.g. patient, doctor, medical device inventor, etc.) who is or was deeply involved in the healthcare system of their country.