Building Science, Technology, and Research Capacity in Developing Countries: Evidence from student mobility and international cooperation between Korea and Guatemala†

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Abstract

Developing countries face numerous challenges in the process of building science, technology, and research capacity; in particular, the formation and accumulation of skilled S&T workforce. The lack of organized and sustainable higher education options (Master and Doctoral programs), nonexistent or low-quality academic programs, and the absence of research-oriented study options are some of the strong contributors for talented students to emigrate to developed countries. At the same time, the consolidation of a global knowledge economy, the internationalization of higher education, and the competition to attract foreign talent in industrialized countries present challenges for underdeveloped nations to retain their already scarce skilled human resources. In this context, student mobility has been used as a policy mechanism to cope with S&T workforce shortages in S&T laggard nations. It has also enabled opportunities for international cooperation to play a key role. While significant literature has been devoted to studying the gains of developed nations with the arrival and potential migration of the mobilized students, few scholarly inquiries have addressed the benefits and losses experienced by their countries of origin. More importantly, limited research can be found on policy options and policy implications for developing countries to deal with the dilemmas presented by the brain-drain/brain-circulation debate. The goal of this article is to study empirical evidence of an international cooperation initiative for student mobility between the Republic of Korea and Guatemala (implemented

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during 2009–2015). The paper analyzes this particular international cooperation experience from the perspective of the different actors involved and attempts to draw policy implications and policy options for developing countries to deal with potential risks and gains derived from international mobility for their S&T capacity building.

Keywords
S&T Capacity Building, Developing Countries, Mobility, S&T International Cooperation, Korea-Guatemala

1. INTRODUCTION

Developing countries face enormous challenges to surpass the trap in which scarce or non-existent science, technology, and research capacity (S&T) condemn them to lag behind. This is particularly critical in the new global knowledge economy paradigm. The backwardness appears inescapable unless a baseline of well-trained local scientists and researchers is formed (Harris, 2004; Wagner, 2001; Watson, Crawford and Farley, 2003). Once a critical mass of human resources is accumulated, absorptive capabilities for advanced knowledge are enhanced. In consequence, the nation may accrue further capacities, enabled by sound and consistent S&T public policies. Admittedly, addressing workforce shortages represents only a partial component of the S&T landscape as public policies are also expected to involve employment options, funding for research, and comprehensive measures to enhance innovation environments. Yet, none of these latter possibilities are possible without human resources (Bin et al., 2016; Meissner, Gokherg, and Shmatko, 2016).

There is a wide consensus about the importance of S&T capacities for underdeveloped countries to solve pressing social problems such as poverty, public health and education (Moreno-Borchart, 2004; Dagnino, 2012). Also, S&T capacities are considered essential for fostering economic growth, wealth creation, and prosperity for the wellbeing of citizens (World Bank, 2008). Nevertheless, numerous barriers hinder the ability of developing countries to create and maintain a research base. Such obstacles range from financial constraints to weak institutions and a lack of scientific tradition (Harris, 2004; Padilla-Perez and Gaudin, 2014). In this scenario, international cooperation offers opportunities to partner S&T advanced nations with S&T laggard countries aiming to build S&T capacity (OECD, 2011; POST, 2004; Wagner et al., 2001). Different mechanisms and schemes have been devised to foster international cooperation in the S&T capacity building, including donor country's research applied in partner countries, fellowships, in-country training, financial support for internships, implementation of joint research projects, amongst others. This study focuses on the mobility of graduate students as a policy option of international cooperation to address the lack of S&T human resources in countries lagging behind, more specifically in Guatemala. This specific mechanism was chosen as it has recurrently been implemented aiming at overcoming the trap of scarce S&T human resources (Bonilla and Kwak, 2015; Gonzalez, 2013). It is considered a trap for countries such as Guatemala because the limiting local context requires external forces such as international cooperation to surpass barriers to form S&T workforce.

The objective of this research is to examine mobility as a particular manifestation of S&T international cooperation. This mechanism could become an enabling route to build science, technology, and research capacities in developing countries. Qualitative research was applied for a case study by collecting data from the stakeholders and other parties involved. From 2009 to 2015, the case study was designed and implemented by two institutions: the Guatemala National Secretariat of Science and Technology (SENACYT) and Kyung Hee University from the Republic of Korea. SENACYT signed the international cooperation agreement with KHU as part of the Guatemala National Plan for Science, Technology, and Innovation 2004-2014 in which the central objective was "to increase the number of trained individuals in science and technology." (SENACYT, 2009) As a result of the initiative, 48 Guatemalan students pursued masters, combined masters and doctoral, and doctoral programs in different fields of science and technology at Kyung Hee University with the conditions, support, and responsibilities detailed in the respective section of this manuscript.

The main objective of this research consists of studying the mobility of students (undergraduate and graduate) from countries that lag in science, technology, and research, such as Guatemala, to an advanced country such as the Republic of Korea. The underlying assumption infers that Korea has a high quality of higher education programs in the areas of science and technology.

The body of this article is divided into various sections. The second section following this introduction focuses on the literature review regarding the role of international cooperation in the building of science and technology capacity in developing countries. The third and fourth sections analyze arguments addressing the drivers and rationale behind the international mobility of students, scientists, and researchers. This study presents the positions of previous studies on the potential benefits and the risks, as framed by the discussion of brain-drain/brain-circulation. Section five provides the readers with the general S&T landscape of Guatemala to further engage with the data presented in the empirical case study in section six. Section seven presents the main findings and discussion of the research results while the concluding eighth and ninth sections consist of concluding remarks, policy implications, and limitations of this inquiry.

2. LITERATURE REVIEW

This section presents a review of the relevant literature regarding three approaches in an inductive narrative. The first focuses on the stance in which international cooperation promotes collaborative initiatives in science and technology while the second examines a review of mobility, a particular mechanism of international cooperation in S&T, and the third on the examination of the brain drain/brain circulation as a manifestation of either counterproductive or positive result of international mobility.

2.1. International Cooperation in Science and Technology Capacity Building

Poor and developing countries face several challenges in the process of building their science, technology, and research base. This situation has been acknowledged by the leading international development organizations (OECD, 2011; United Nations, 2016; World Bank, 2008), which called for attention the role that global cooperation might play in this regard. Harris (2004:7) defines S&T capacity building as "partnerships between developed and developing countries aiming at strengthening research, technology, and scientific capacities" in the second group of countries. The same author considers the S&T capacity building process as rich, fascinating, very complex, and often oversimplified.

The United Nations (2016:131) has called for commitment at the international level to "support efforts of developing countries to strengthening their scientific, technological and innovative capacity." Also, the World Bank (2008:11) proposes compelling questions regarding the S&T capacity building process: "What precisely is meant by STI capacity building? What capacities must be built? How have countries built their capacities?" These questions are not susceptible to straightforward and simple answers because measuring national S&T and research capacities in developing countries is complex and elusive (POST, 2004). One way to respond to these questions is considering the involvement of two types of capacities: the capacity to use existing knowledge and the capacity to produce and use new knowledge. It also involves the consideration of building capacity at four distinct levels (World Bank 2008:11): a) government policymaking, b) labor force skills and training, c) enterprise innovation, and d) education and training institutions and research institutions. A second approach (WSDD 2002:2) proposed is understanding capacity building for science and technology "to all levels of skills and the full array of S&T infrastructure and governmental and other support necessary for a country to create and maintain a productive an independent S&T sector." Finally, MOST (2004:2) suggests a third approach regarding building capacity in science & technology as "the ability of individuals, organizations or societies to meet their need," however, without sufficient knowledge and skills in many areas including S&T, developing countries may find this approach difficult to accomplish.

Capacity building is a widely recognized priority in the development field (OECD, 2011), and S&T capacity building through international cooperation can provide significant opportunities for realizing its benefits. It may take different forms depending on the channels for its provision. It can be done through official development assistance - ODA (government to government), among private organizations (universities, research institutes), or between individuals (scientific collaboration). MOST (2004:2) outlines four forms by which international collaborations for building S&T and research capacity have taken place:

- **Donor country research:** Researchers from developed countries study the developing countries, occasionally involving local researchers.
- **In-country training**: Developed countries train and teach within developing country institutions.
- **Financial support**: Developing country universities and research programs are funded directly by donors.
- **Fellowships:** People from developing countries attend courses and gain qualifications in developed countries.

The dimension of S&T and research capacity building about which the present research focuses depends on the formation and accumulation of S&T human capital in developing countries. As indicated by Harris (2004:9), the "key to scientific success resides in human resources." In the knowledge economy, a high priority is placed on a well-trained workforce, especially in the areas of science and engineering. WSSD (2002:3) concluded that "efforts should be made to support the mobility of scientists and engineers to promote the exchange of experience and capacity that will benefit all the parties." Emphasis on the S&T capacity building must be on training in an equitable, respectful way and on establishing long-lasting, sustainable partnerships. In other words, this article revises the category of fellowships or scholarships to mean the funding of the mobility of individuals from the partner-sending country (donor) to receive formal and advanced education in the partner-host country (beneficiary).

2.2. Mobility, Drivers, and Rationale

The movement of students, scientists, researchers, and scholars has occurred since the ancient times; famous explorers such as Darwin and Crusoe come to mind. However, new ways of transportation, lower costs of mobilization (time and resources), and the undeniable force of globalization in education and academy have triggered higher rates of mobilization as never seen before (Gaillard and Gaillard, 1997; Freitas, Levatino, and Pécoud, 2012; Solimano, 2002). Interestingly, until recently, such mobilization used to happened mostly among the developed nations. In the late 1960s and the early 1970s, this mobility involving the developing countries became increasingly common and frequent (Gaillard and Gaillard, 1997).

Most of the available literature on mobility focuses on data and experiences occurring in developed countries. Different authors have acknowledged that mobility among graduate students, researchers, and faculty is quite limited in developing countries (Jacob and Meek, 2013; Rodríguez, Bustillo and Mariel, 2011; Wagner et al. 2001). However, new perspectives have arisen portraying the participation of underdeveloped nations in the circulation of scientists, technicians, scholars, researchers and higher education students (Vessuri, 1996; Wei, 2012). An enticing question may frame this discussion: what are the drivers, determinants, and rationale behind this international mobility from the South to the North?

Hebbe Vessuri (1996) asked a similar question. She inquired what factors push or pull scientists and researchers to mobilize themselves abroad. This author proposed at least three drivers: the validation mechanism, the labor market functionality and the borderless nature of science. The first driver involves the location of qualification, which is mostly concentrated in Western countries. In this sense, scientists, scholars, and students from developing regions may be driven by the desire to be recognized internationally (as they come from countries without scientific tradition). They might be seeking the merit of evaluation criteria based on publications with recognized impact indexes, desiring to establish contacts with foreign researchers, and wanting to achieve and maintain international standards. The second impacting factors obey the characteristics of the international labor market, the uneven distribution of income, the political-economic determination of knowledge and the dominant ideology. As human resources flow between the economic centers and the underdeveloped peripheries, it consolidates the center and periphery model, which assumes scientific exchanges between metropolis and province. The third driver regards the borderless characteristic of science. The nature of the scientific profession and the education of researchers entails a predisposition for mobility since their formation and experience is, to a good extent, irrelevant to local work markets and is directly functional for the labor markets of developed centers (Vessuri, 1996:8). Scientists may benefit from the differences in the work environment because the weakness of a system may be less restrictive to an outsider. It may permit the scientist to acquire a competitive vein upon his/her return to his/her customary workplace. Gaillard and Gaillard (1997) suggested a more pragmatic analysis by considering different drivers for short-term and for permanent mobility. On the one hand, short-term movements between nations by researchers have become fundamental to the normal research activity of open mobility without barriers, as this is what science needs at present. Thus, public policies of developed countries encourage such mobility. In contrast, permanent mobility (migration) might be an emotional response to the absence of the home state policies "which make a scientist feel an orphan of support and social demand for his/her work" (Gaillard and Gaillard, 1997:7). An important individual component that influences the way how a scientific/research career is pursued (back home) is the "limitations due to lack of funding, complicated access to modern equipment, absence of groups of researchers, impossibility of networking, and other demands." In a similar approach, Jacob and Meek (2013:335) proposed considering the drivers of three types of researcher mobility: long-term mobility, generally involving the employment of the researcher and/or permanent change of residence; short-term mobility; and short-term, recurrent and repetitive mobility. The first has been traditionally considered as a zero-sum game, although increasingly the physical separation of the country of origin is no longer equated to a loss. The second and third types of mobility reflect the enthusiasm for technology transfer (Woolley et al., 2008).

Other studies have focused specifically on the international mobility of students. This is the case explored by Gribble (2008) who discussed several factors contributing to the growth in the number of students from developing regions pursuing higher education (and scientific/research training) in industrialized nations. The author enlisted, among such factors, those corresponding to the reality of the sending country, they are the under-supply of university places of the sending country, resulting in poor economies being unable to satisfy the demand for tertiary education. Another factor could be the expectation that foreign study will confer professional and business advantages to the mobilized students. Conversely, from the receiving countries, immigration policies have been designed and implemented to attract talented international students to solve local skill shortages. Some of these policies include work permits, researcher visas, and other managed immigration measures. Wei (2012) proposed a binary perspective to discuss the determinants facilitating the international student mobility across borders: educational and economic. In the first group, the author included higher education coverage, quality of education, and investment in tertiary education. In the second group, Wei (2013:110) included the "per capita GDP gap between countries and the economic integration between the inflow and the outflow nations." Finally, Rodriguez, Bustillo, and Mariel (2011) studied the factors influencing the flow of students across borders from the receiving country's perspective. They included the country size, cost of living, the distance from the home country, educational background, university quality, the host country's language, and the climate as the factors influencing these flows.

It is important to note that the literature addresses general trends explaining mobility, while other particular motivations, drivers, or determinants such as political instability, seeking of refugee status, and other similar situations are not considered for the purpose of the present analysis.

2.3. Brain drain and Brain circulation

The expression *brain drain* was coined to condemn the flight of intelligent minds from developing countries to rich countries and was conceived as a one-way phenomenon, because it is often hastily combined and confused with the notion of loss conveyed in the term "drain," with the migration of educated and professional people (Gaillard and Gaillard, 1997). In 1963, a document from the Royal Society used the term "brain drain" in the context after the Second World War to describe the migration of British intellectuals and scientists to the United States. This same word has been applied to migration from poor regions to the Western world. Gaillard and Gaillard (1997) summarize the historical discussion and the semantic evolution of the term "brain drain." This expression captured attention in the 1960s and 1970s as a terrible evil equated to a process resulting in the depletion of already scarce, highly-skilled (educated) human resources from the South to the West. In the 1980s and 1990s, the expression gained impetus again due to the brain return of Asian Diasporas. A variety of expressions have accompanied the shifts in its application since the coinage of the term: "brain gain," "brain overflow," "reverse technology transfer," "brain waste," "brain exodus," "transit brain drain," "delayed return," "brain return," and "brain mobility," to mention a few. Meanwhile, with the turn of the new millennium, the use of other words such as "mobility," "brain exchange," or "brain circulation" was introduced as a nuance to the concepts, imprinting a more positive or at least less adverse sense. Nevertheless, the term "brain drain" remains widely used.

Freitas, Levatino, and Pécoud (2012) proposed that their analysis departed from the understanding of the term "brain" and to related notions such as "skills" or "qualifications." According to the OECD, highly skilled individuals are those who have completed tertiary education, which corresponds to a university degree in most countries. University students are included in this category because although they are not already trained brains, they are trainable. In many cases, their education abroad is financed by Official Development Assistance (ODA), other forms of aid, or by tertiary education institutions, usually through scholarships or fellowships.

Different authors (Freitas, Levatino, and Pécoud, 2012; Gaillard and Gaillard, 1997; Vessuri, 1996) call for attention the dilemmas presented by the skilled migration (another term used for brain drain/brain circulation, with less connotation attached) and the great complexity of the scientific and policy debates. The dichotomy and other trade-offs between the conflicting rights continue to arise: the right to development, the right to education, the right to migrate, and the right to equality. Ethical and political imperatives (such as global justice, individual freedom, and control of people's mobility) as well as actors (states, corporations, international cooperation agencies, institutions, and migrants themselves) explain the problems with setting out skilled migration as a zero-sum game. The loss of skilled workforce can be thought as both cause and consequence of underdevelopment. This is why alternative approaches such as brain gain and brain circulation become critical in the search for balance. Through "brain gain," countries are provided access to science which is seen as a justification for the large-scale migration of students from developing countries to universities in the North, as long as these students return to their home country after completing their programs (Gaillard and Gaillard, 1997: 200).

Also, mobility provides scholars with formidable potential for teaching and research, which would be lost if they were not able to enter the sanctuaries of science and knowledge. Also, mobility can turn into a precondition of scientific creation and dissemination of knowledge. Jacob and Meek (2013) even sustain that mobility of scientific labor is an indispensable prerequisite for building capacity and world-class excellence, and the need for international cooperation is greater today than in the past.

The later arguments support such claims as the essence of science, and scientific endeavors are expected to have a wider impact globally when they are not restricted by boundaries. Such international cooperation initiatives would involve the interests of both developing and developed countries, which are increasingly recognizing the value of diversity in science/research. This is not just a way of "helping" the poor, but also a way to do better science.[1]

3. BACKGROUND FOR THE CASE STUDY

3.1. The Context of Science and Technology in Guatemala

Guatemala is the biggest economy of the Central American sub-region. Along with El Salvador, Honduras, Nicaragua, Costa Rica, and Panamá, this Latin American country forms part of the isthmus located in the central region of the Americas. With an estimated population of nearly 17 million in 2017 (last general census in 2002), the nation holds some of the lower indicators in terms of science, technology, and research capacities in the region (Padilla-Pérez and Gaudin, 2014; RedCTI, 2018; UNESCO, 2017). In fact, all the Central American countries have been classified by Wagner et al. (2001) as *Scientifically Lagging Behind* nations or those who fall below or well-below the international means of all components of the S&T capacity index. As assessed by Wagner et al. (2001:15), "these countries have little or no capacity to conduct international level science," which may offer opportunities for capacity development over time.

Compared to other countries, Guatemala has fewer researchers and overall funding from the government directed to science and research. In this Central American country, the number of full-time researchers is 27 per a million inhabitants, a figure 16 times lower than the average of Latin

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[1] Source: https://www.nature.com/news/diversity-1.15913

America and 262 times lower than the average in developed nations (UNESCO, 2017). These numbers are worrisome, as the economy of a developing country such as Guatemala requires further research and innovation capacities in order to use them for its own socio-economic development process. In the case of Guatemala, the size of the scientific community should be at least 45 times higher (between 1,000 and 1,200 full-time researchers). Another limitation in Guatemala is that it invests only 0.029% of its GDP to R&D activities, severely limiting scientific and technological advancement. This is 14 times lower than the investment in Sub-Saharan Africa, 25 times lower than in Latin America and the Caribbean, 85 times lower than the average in Western Europe, and nearly 200 times less than the investment in Korea or Israel. As the consequence of the minimum investment, the scientific production significantly suffers in terms of international specialized journals: Guatemala produces 11 articles per million inhabitants. The same figure in Chile, a relatively more advanced Latin American country, is 45 times higher.

This dire scenario is also evident in the production of highly educated human resources. According to Bonilla and Kwak (2014), as much as 96.5% of the population in Guatemala lacks a complete tertiary education. Among those who manage to complete tertiary education, most graduate with degrees in undergraduate and non-degree technical programs. Few specializations and master programs are available, and only a few doctoral programs are offered by local institutions. As for the field of study, a pervasive emphasis is placed exclusively on teaching-oriented activities (without the research component), perpetuating the reproduction of knowledge instead of the production of new knowledge. As a result, in Guatemala, research, science, and technology are fields not yet explored or prioritized in higher education institutions. Guatemala desperately needs to double its efforts to accumulate a skilled and well-prepared workforce that can respond to the increasing pressures of globalization and the changing productive paradigms. Disturbingly, though, the higher education system in Guatemala has proven to be insufficient in producing the highly educated workforce needed to meet the market demand (Bonilla and Kwak, 2014). As indicated by the World Bank (2008:14), "An educated, trained workforce is a [condition] sine qua non for STI capacity building," which contrasts with the dire reality of Guatemala, a country with an acute shortage of skilled and well-prepared workforce able to respond to the pressing demands of the new global economic order.

A positive remark is presented by Padilla-Perez and Gaudin (2014) in their assessment of the science, technology, and research landscape in the Central American sub-region. They appraised the increasing recognition among Central American policy makers of the importance of science, technology, and innovation for the development of the sub-region during the last three decades. However, they also identified several barriers that the governments of these countries, including Guatemala, face when designing and implementing STI policies. These barriers are related to poor funding, the prevalence of short-vision and lack of long-term planning, the inexistence of the institutional culture to monitor and evaluate programs and policies, and weak coordination among the public bodies involved. As such, international S&T cooperation could play a decisive role in partnering with Guatemala by providing different mechanisms to overcome the indicators and the general situation illustrated in this section.

3.2. International Cooperation Korea-Guatemala: Mobility of Science and Technology Graduate Students

The empirical evidence for the present work was collected from an in-depth case study of an international cooperation experience of student mobility. This initiative was formalized by the signature of an international cooperation agreement between the Guatemala National Secretariat of Science and Technology (SENACYT) and Kyung Hee University (KHU) of the Republic of Korea on January 7th, 2009. This document contained the general basis for the SENACYT-KHU Science and Technology Scholarship Program.

According to the Yearly Book Report of SENACYT (2009:25), the purpose of such cooperation program was framed in the "National Plan for Science and Technology 2004-2014 which included recommendations on the convenience of increasing the number of students abroad in order to put them in contact with the latest developments in science and technology." The institutions promoting such initiative were the two signing parties -SENACYT and KHU- with the support of the Diplomatic Mission of Guatemala in the Republic of Korea.

The mechanism to operate the international cooperation agreement involved responsibilities among the three main parties. Table 1 summarizes the commitments each participating party would fulfill for duration of the agreement.

TABLE 1. Responsibilities Acquired per Participating Party SENACYT-KHU International Cooperation Agreement

Party	Responsibilities
SENACYT*	- Provision of the round-trip air ticket between Guatemala City and Seoul (at the beginning and completion of the study program) - Logistics for the reception and shipping of the scholarship application - Monitoring and Follow-up of the academic performance of the scholarship awardees
KHU*	- Admission fee waiver - Tuition fee waiver - Monthly stipend for living expenses (shared with the research laboratories) - Access to all universities services of regular students to the Guatemalan scholarship awardees
Mobilized students from Guatemala**	- Fulfill diverse academic responsibilities according to the respective study program - Obtain high academic performance - Follow university regulations - Perform their research tasks assigned by the respective laboratory - Send periodic study program progress reports to SENACYT - Upon graduation, return to Guatemala, and engage in the new area of specialization for at least the same period to the duration of the program

*Source: *SENACYT-KHU Agreement (2009a), **SENACYT-Scholarship awardee administrative Agreement (2009b)*

4. RESEARCH QUESTIONS

The four guiding questions for the present study were designed according to the set scope and focus of the inquiry. In general, developing countries have limited capacity to identify where and how S&T policies can help address their numerous social, economic, environmental, security, and other pressing problems. The first resources they need desperately are a skilled and highly educated workforce that may take the leadership in government institutions, the private sector, and universities and other spheres of influence and action. As stated by the World Bank (2008:1), "in today's increasingly competitive global economy, science, technology, and innovation capacity building can no longer be seen as a luxury, suitable primarily for wealthier, more economically dynamic countries." Rather, to foster sustainable development S&T capacity building, it is an absolute necessity in developing countries.

> "S&T capacity building involves two types of capacity: a) To acquire and use existing knowledge, and b) To produce and use new knowledge. It can be analyzed in for distinct levels: Government policy making, **Labor force skills and training**, Enterprise innovation, Education and training institutions and research institutes" (World Bank, 2008:1)

The scope of this research is marked in bold above, as reflected in the research questions a and b presented below. This focus limits the research topic to international cooperation in S&T, and more specifically, to a mechanism widely used in joint initiatives between partner countries (developing and developed), which characterizes the mobility. In this framework, such construct (mobility) resulted in question c. Finally, from the empirical evidence collected out of the particular international cooperation in S&T though student mobility between Korea and Guatemala resulted in question d.

a. In regard to the Guatemalan science, technology, and research landscape, which challenges are faced by developing countries to build human S&T capacities?
b. How can international cooperation play a role in partnering with developing countries such as Guatemala to address such challenges?
c. What are the benefits and potential risks of international mobility as a mechanism to build S&T human capacity?
d. What policy implications can be drawn from the SENACYT-KHU Science and Technology scholarship experience?

In section six where the findings are presented and discussed, the researchers propose possible ways to answer the research questions.

5. METHODOLOGY AND DATA SOURCE

The methodology of this case study allows for a better understanding of the country-specific context. We paid attention to the institutional participation in the case of SENACYT and KHU, as well as individual motivations and expectations of the mobilized students. As empirical evidence for this research, the data was collected through three main instruments. First, the 48 mobilized students completed a comprehensive online survey. Second, representatives or officials on behalf of SENACYT and KHU answered a semi-structured questionnaire. And third, the method of desk review was used to collect existing data from public records on the international cooperation initiative. In addition, organizations and other institutions with some degree of participation in the SENACYT-KHU Science and Technology Scholarship program were consulted to increase the rigor and validity of the data. These were the Guatemala National Secretariat of Planning and Programming of the Presidency (SEGEPLAN), the institution in charge of administering scholarships provided by international cooperation initiatives; The San Carlos of Guatemala University (USAC), the rector institution of higher education in Guatemala; and the Institute for the Development of Higher Education in Guatemala (INDESGUA), a non-profit organization pointed by several scholarship awardees as their guide in the application process. The language used during the data collection was Spanish, with English used only to collect data from Kyung Hee University. Table 2 presents a summary of the sources.

TABLE 2. Stakeholders and Sources of Data: SENACYT-KHU Science and Technology Scholarship Program 2009-2015

Stakeholders	No. Target Data Sources	Effective Response	Data Collection Instrument
SENACYT	3	2	Semi-Structured Questionnaire
KHU	2	1	Semi-Structured Questionnaire
Guatemala mobilized students	48	30	Online Comprehensive Survey
Embassy of Guatemala in the Republic of Korea	2	2	Semi-Structured Questionnaire
SEGEPLAN*	2	0	Semi-Structured Questionnaire
USAC**	2	1	Semi-Structured Questionnaire
INDESGUA***	2	2	Semi-Structured Questionnaire
REDCTI****	2	2	Semi-Structured Questionnaire

Guatemala General Secretariat of Planning and Programing of the Presidency, ** San Carlos of Guatemala University, * Institute for the Development of Higher Education in Guatemala, ****International Network of Guatemalan Scientist*

Unlike quantitative research, which applies statistical methods for establishing validity and reliability of research findings, the present inquiry followed qualitative research approach aimed to design and incorporate methodological strategies to ensure the trustworthiness of the findings (Galofshani, 2003; Shenton, 2004). Triangulation of the data collection and data sources was used to enhance credibility.

5.1. Online Comprehensive Survey

A database of the total of scholarship awardees (mobilized students) was built based on public records provided by SENACYT, Kyung Hee University, the Embassy of Korea in Guatemala and

INDESGUA. A total of 48 scholarships were registered during the 2009-2015 period. Although the agreement remains valid and active, changes in the conditions of the support provided by KHU (such as reduction in the stipend provided, increase in the share of autonomous responsibilities of the research laboratory) resulted in a discontinuation of the outflow of students. The last reported batch traveled to Korea during the first semester of 2015.

A comprehensive survey of 31 items was sent to the database online using the platform *SurveyMonkey*. The items in the survey were designed to collect data from the mobilized students on ten specific aspects:

TABLE 3. Topics Covered by the 31 Items Included in the Comprehensive Survey

1. Study Program	6. Assessment on the fulfillment of responsibilities by stakeholder
2. Scholarship Awardee Profile	7. Outcome and Impact indicators of participation
3. Home-Country Mobility Specific Factors	8. Indicators of brain brain-drain/brain-gain for the graduated returned students
4. Host-Country Mobility Specific Factors	9. Indicators of brain-drain/brain-gain for the graduated students residing abroad
5. Aspects of difficulty to overcome in the program	10. Expectations of brain-drain/brain-gain for the active (still not graduated) students

Source: authors own elaboration

First, the survey was sent to the email address of 44 out of 48 scholarship awardees (four abandoned the program in very early stages) with a complete explanation of the purpose of the data collection and the protocol guidelines of how to freely withdrawal at any moment. Responses were collected anonymously with disregard of the respondent's identity. Also, an invitation was sent using social media to encourage participants to fill out the survey. Participation was voluntary and reached a total of 30 effective responses out of 44. The comprehensive survey was available for completion between February 1st, to 20th, 2018. Complementary information was collected through the revision of public online profiles such as LinkedIn, Research Gate, and Google Scholar.

5.2. Semi-structured Questionnaires

Semi-structured questionnaires were sent via email to representatives or officers of the institutions/organizations with different degrees of participation from the SENACYT-KHU Science and Technology Scholarship Program 2009–2015 (see Table 2). Data collection occurred from January 15th to February 15th, 2018.

5.3. Desk-Review

Different registries, public records, and various documents were reviewed for data collection. Particularly the SENACYT Yearly Books corresponding to 2009 to 2015. Each of those documents makes specific mentions of the SENACYT-KHU Science and Technology Scholarship Program were included (SENACYT, 2009a). Also, a copy of the Preliminary Agreement of the International Cooperation instrument was available for this research. In addition, a sample copy of the administrative agreement signed by SENACYT and a scholarship awardee was also accessible. Finally, different registries and documents issued by Kyung Hee University were also consulted.

6. FINDINGS AND DISCUSSION

In this section, the findings and discussion are organized following the research questions and aimed at presenting possible answers to the inquiries that guided this research.

> What are the challenges faced by developing countries with the characteristics of the Guatemalan science, technology, and research landscape, to build human S&T capacities?

6.1. Home-country Specific Drivers for Mobility: the Case of Guatemala

International mobility of students can be explained by the contributing factors present both in the home (sending) country as well as the conditions offered by the host (receiving) country. The readers were presented in section five of this article with a current portray of the science, technology, and research landscape observed in Guatemala. As in other small, poor and developing countries of similar characteristics, talented students are not offered with the possibilities to remain in the country to pursue advanced higher education; they are in a sense left with no option but to seek for study/train programs overseas.

Scholarship awardees were asked: *Considering the options for you to continue higher education in Guatemala, please rate the importance of the reasons why you pursued a study program overseas.*

Table 4 below summarizes the main reasons why students pursued their studies abroad. According to the student's responses, the most important driver was the impossibility to study the desired program in a domestic higher education institution. Bonilla and Kwak (2014:27-31) presented evidence of the challenges that Guatemala faces in the formation of highly educated human resources. From the supply-side perspective, they concluded that the entire higher education system in Guatemala lacks quantity and quality of study programs. In addition, such programs lacked diversity in the academic fields of concentration; they are overly concentrated in social sciences with a pervasive emphasis on technical and undergraduate degrees. Also, there are very limited in research-oriented activities in the few master and doctoral programs available.

The main focus of university education in Guatemala is teaching with an extremely little emphasis on scholarly production.

TABLE 4. Home-Country Mobility Drivers

Reason / Conditions of Home-Country for studying abroad	Ranking in importance after weighted average
A similar study program was not available (was not offered in Guatemala)	1
A similar study program was available but with a lesser quality	2
Dedication to a full-time study program was not possible in Guatemala	3
A similar study program was available but not affordable (high tuition fees, admission fees, etc.)	4
Studying in my home country would not bring the international experience	5
Local (Guatemalan) universities are not well positioned in international rankings	6

The rest of reasons referred by the respondents were closely related to the context of Guatemala and were included further in descriptive open comments of the respondents, who were given the option of writing other reasons as they were willing the share. Here some examples:

> "I applied to continue my studies abroad because in Guatemala a similar doctoral program was not available. What is more, academic research is totally nonexistent in my discipline and the industry does not have firms, factories or companies involved in the area for possible technology to be developed." [respondent No. 7]

> "At the moment of my application, there was a similar program in one of the private universities in Guatemala. However, it involved attendance only 2 hours two-days a week during evenings, which meant questionable academic standards." [respondent No. 11]

> "I did not really look for a similar study program in Guatemala because even if it existed, I had not the means to support myself or to pay for expenses. In order to study in my area, I need to dedicate full time to the program and working to earn a salary and studying full time was not possible." [respondent No. 16]

6.2. Human S&T Capacity Building

During the period of operation of the SENACYT-KHU Science and Technology Scholarship Program, a total of 48 scholarships were awarded. The areas of study included as many as 14 fields, mostly concentrated in engineering and sciences (see Table 5). Within the fields, different highly specialized laboratories and research groups received the Guatemalan students. For example, one of the fields with a higher concentration of scholarship awardees was Computer Engineering. This area involved the laboratories of Image Processing, Internet Computing and Security, and Ubiquitous Computing and Networking. Another field with greater presence was Industrial Engineering, involving laboratories such as Quality Engineering and Data Analysis, Business Process Management, and Artificial Industrial Engineering. The third field with the highest level of participation was Mechanical Engineering, including various laboratories, e.g., Energy and Mass Circulation, Advanced Materials and Nanocomposite Structures, Material Theory.

As for the level of the degree, the vast majority of 63% received (or will receive) Master of Science, followed by 23% concentrated in Combined Master and Ph.D. degrees. Finally, 7% of the students were awarded scholarships for undergraduate and doctoral degrees. In terms of the number of hours devoted to research activities, the majority of respondents indicated that, on average, they dedicated between 9 and 10 hours every day (60 hours a week), followed by a second group who sustained they spend more than 60 hours weekly to research activities assigned by their laboratories.

TABLE 5. Area of Study / Degree – SENACYT-KHU Science and Technology Scholarship Program

	Program of Study – Degree obtained /to be obtained				
Field (Area) of Study	Undergraduate	Master	Combined Master and Ph.D.	Ph. D.	TOTAL
Biomedical Engineering		2	3		5
Chemical Engineering		4		1	5
Computer Engineering	1	6		1	8
Computer Science		1	2		3
Electric Engineering		1			1
Electronic Engineer	1	1	1	1	4
Genetic Engineering	1		1		2
Industrial Engineering		5	1	1	7
Life Sciences		1	1		2
Mechanical Engineering	1	5			6
Nuclear Engineering			1		1
Radio Engineering		1	1		2
Biotechnology		2			2
TOTAL	4	29	11	4	48

These indicators illustrate details of the study program, the disciplines, and the research laboratories in which students developed their activities as well as the general distribution in terms of the level of education and training. As mentioned, earlier, four scholarship awardees abandoned the program without completion, with four still active and pending graduating, and a total of 40 who completed their study programs and graduated, obtaining their respective degrees. Most of the students took between two to three years to complete their studies (44%), followed by a second group who reported duration of four and a half to six years (30%). A third group (23%) indicated a duration of three and a half to four years. Only one respondent indicated a duration of the program of over six years to complete the program.

6.3. Profile of the Mobilized Students

In this item, the researchers identified the profile of the scholarship awardees, their occupation or employment status at the time of application to the program, and their expectations of work upon return. In addition, this inquiry aimed at exploring the contributing factors that motivated the students to apply. From the 48 scholarship awardees, the number of men was more than double of the women who participated (see table 6). This is consistent with the general trend of gender differences in the fields of science, technology, and engineering.

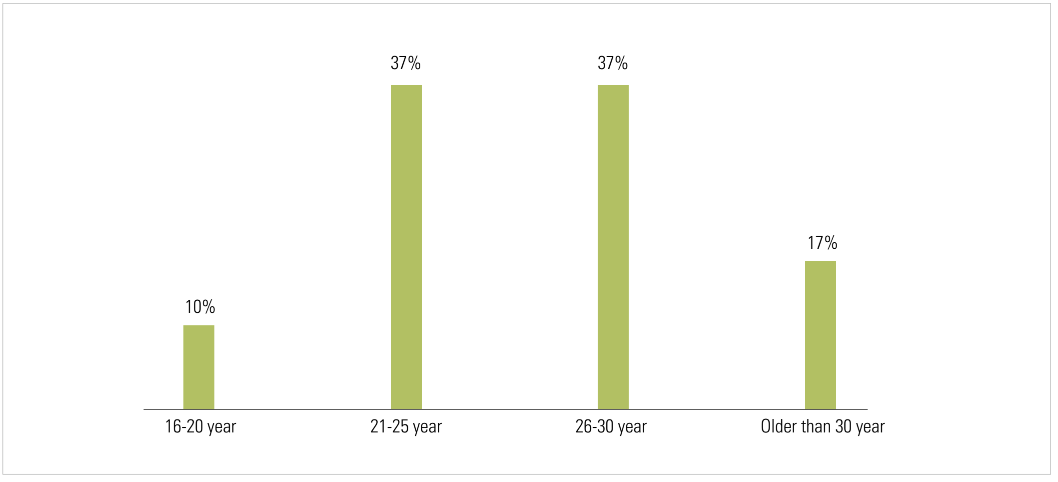
TABLE 6. Scholarship Awardees by Gender

Gender	No.	%
Female	15	31
Male	33	69
Total:	48	100

n=48

As for their age at the time of the scholarship application, two equal groups (40% each) reported being 21–25 and 26–30 years old. The third largest group (16%) was older than 30 years old (see Figure 1).

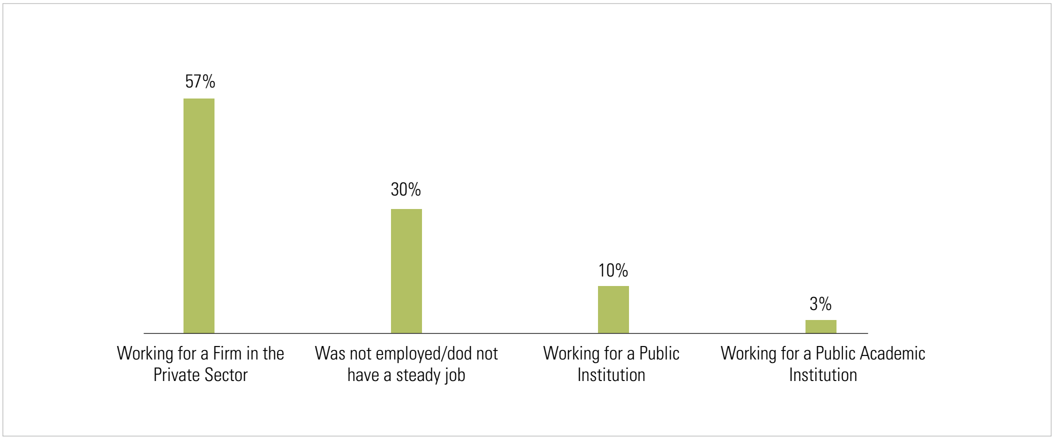
FIGURE 1. Age of the Scholarship Awardees at the Time of Application to the Program



The respondents were asked two questions regarding the sector of work/employment at the time of the application to the scholarship program and the expectation of work/employment upon graduation. These questions were used to explore the intention of the scholarship awardees of remaining in their occupation or transit to a more knowledge-intensive activity, and whether they would return to Guatemala or remain overseas.

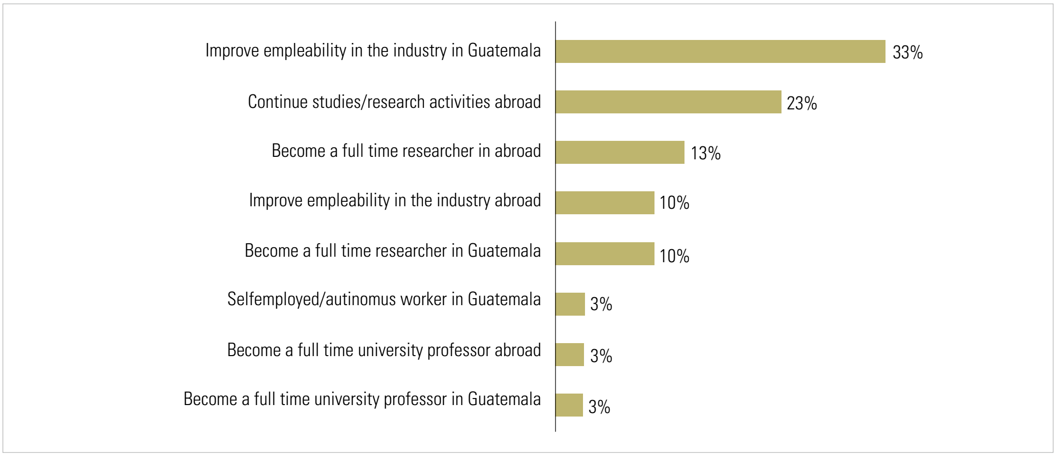
Figure 2 shows an important concentration of respondents working for the private sector, firms, or industry-related organizations at the time of application, with slightly less than 60%. The second biggest group was not working or did not have a permanent job.

FIGURE 2. Sector of Work/Employment at the Time of Application to the Program



The findings in Figure 3 below appear consistent with the expectations of a significant number of the scholarship awardees to remain in their original sector of work: industry and firms in the private sector. This data is worthy of further analysis, as indicators of R&D activities in the private sector of Guatemala are scarce "while private enterprises and industry associations do not generally demand active public support in this area." (Padilla-Pérez and Gaudin, 2014:8) In general, highly trained researchers and scientists working in the private sector perform activities more closely related to operations, marketing, and sales. With this perspective, the private sector is regarded as the best employer in terms of economic compensation for highly educated human resources in Guatemala. Bonilla and Kwak (2014:34) presented empirical data sustaining that "the private sector, understood as business oriented/profit-seeking organizations (firms) is the area of the work context in Guatemala that best uses highly educated human resources."

FIGURE 3. Work/Employment Expectations upon Graduation



How can international cooperation play a role in partnering with developing countries such as Guatemala to address such challenges?

Considering developing countries are responsible for overcoming their own barriers, these country's success is complemented by international cooperation. With this perspective, partner (advanced) countries provide support and opportunities which would otherwise be unavailable for the beneficiary countries. The role of international cooperation could open financial support and access for better practices in science, technology, and research. At the same time, we must pay attention to the hardships and difficulties presented by these international cooperation mechanisms.

6.4. International Cooperation Sharing the Costs to Build S&T Capacity

The financial resources invested in the study programs for the Guatemalan scholarship awardees, including their mobilization, living costs and complementary expenses were substantial. Considering the size of the Guatemalan economy, a country classified as a lower-middle income nation with a per capita income of USD 4,140, the financial amount and resources invested in these Guatemalan scholarship awardees, including their mobilization, living costs, and complementary expenses, was substantial. Overall, the estimated global costs of the SENACYT-KHU Science and Technology Scholarship Program reached USD 2,509,540 in total. This translates into nearly 19 million quetzals (Q=Guatemalan currency; the exchange rate on Feb. 2018). This figure shows the importance of the role played by international cooperation, as the annual budget of SENACYT for 2017 (Ministry of Finance, 2017) was Q33,485,000 (approximately USD 4,465,000), from which the biggest share was devoted to the administrative operations of the institution with very limited resources devoted to the development of S&T capacities (Cobar, 2017).

TABLE 7. Estimated costs per study program / SENACYT-KHU Science and Technology Scholarship Program

Level of Study	Undergraduate (3)	Master (26)	Ph.D. (4)	Combined (Master & Ph. D.) (11)
Individual	US$71,880	US$44,300	US$51,500	US$85,100
Total	US$215,640	US$1,151,800	US$206,000	US$936,100

n= 44 (48-4 abandoned) Sources: SENACYT (2011: 32) and Embassy of Guatemala in Korea (2018).

6.5. Access to Advanced Knowledge and Better S&T Practices Absent in the Sending Country

Destination-country specific drivers: the case of Korea

Various factors influenced where the international students chose to pursue their higher education. Numerous studies have explored these drivers (Mazarol and Soutar, 2002; Rodriguez, Bustillo and Mariel, 2011; Way, 2013). A variety of explored factors ranged from historical and cultural factors (colonial and cultural ties between the home and the host country), sociological drivers (shared language), to economic (trade between the countries) and geographic drivers (proximity and climate). As for the present research, in a similar exercise to the one described in the previous section, scholarship awardees were asked:

Considering the factors for you to continue higher education in a foreign country, please rate the reasons why you specifically chose to study in Korea.

The principal driver in the decision of Guatemalan students selecting Korea as their academic destination was "the (advanced) state of science and technology in the country." This was followed by the prospect of employment after graduation either in the Republic of Korea or being employed by a Korean company. These drivers illustrate the importance of S&T capacities in the host-country, considering that the more traditional destination for Latin American students as other studies show further influence United States (prestige of universities and presence of a significant community of Guatemalan residents), Spain (shared language and colonial-historical ties), etc. Table 8 below presents the main reasons expressed by the respondents.

TABLE 8. Host-Country Mobility Drivers

	Ranking in importance after weighted average
State (advanced) of Science and Technology	1
Prospect of employment after graduation (either in Korea or by Korean companies)	2
Language accessibility (studies were conducted in English, Korean language was not compulsory)	3
Prestige/ranking of the host university	4
Reasonable living costs	5
Exposure to cultural diversity	6
Geographic location	7

Also, the recent increment of foreign student's movement to Korea can be partially explained by recent policies of this nation such as the *Study Korea 2020 project* created by the Education Reform Council of the Ministry of Education, Science and Technology. This initiative started in 2004 and aimed to attract 200,000 foreign students to Korea by 2020. The number of international students in higher education in Korea grew from 12,314 in 2003 to 104,262 in 2016 (MOE, 2016). The policy aims at attracting foreign students as "they help to the internationalization target for Korean universities" (MOE, 2016) as enrollment of Korean student is decreasing due to demographic issues (aging of society and low birth rate).

6.6. Factors Representing Difficulties Overtaken during the Duration of the Study Program

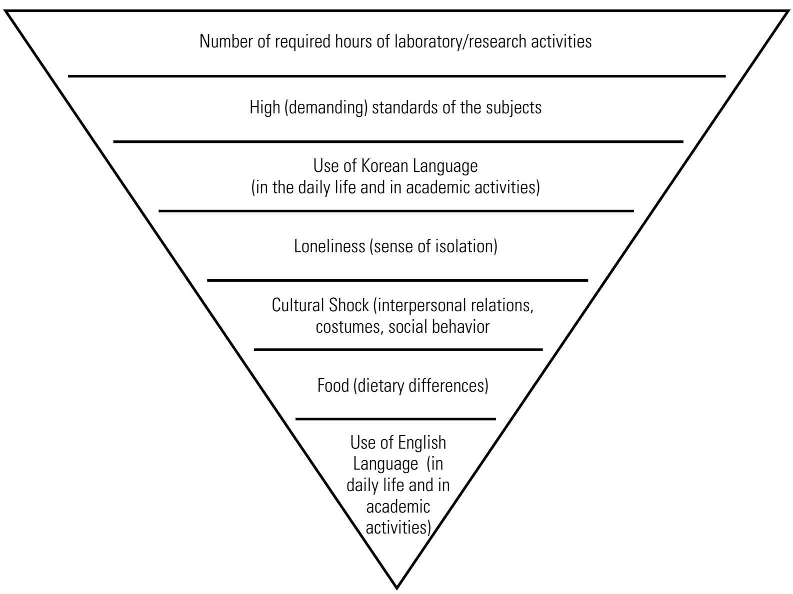
The rate of successful completion of the SENACYT-KHU Science and Technology Scholarship Program during the period 2009-2015 is considerably high. Of the 48 scholarships awarded, only 3% of the participants abandoned the program. These students who did not complete the program were asked to fulfill certain administrative responsibilities with SENACYT to end their participation. Of the remaining 44, a total of 40 (as of February 2018) or 83.3% have completed their programs, successfully graduated, and obtained their respective academic degrees. The remaining 8 or 3% continue to pursue their programs of study.

Several reasons could influence the mobilized students' decisions to remain in their programs, overcoming various challenges, or in contrast choose to withdraw themselves from their study programs. Respondents were given the list of statements to rate in terms of the level of difficulty they experienced, and provided further insights regarding the challenges they faced during their study and living experiences in the Republic of Korea.

Figure 4 presents their responses in descending order. The challenges placed on top of the inverted pyramid illustrate the conditions that represented the strongest level of difficulties with statements placed at the bottom.

The majority of respondents remarked that the required number of hours devoted to research/ laboratory activities represented the strongest level of difficulty. The second biggest difficulty was the high commitment required by the subjects of study. In other works, the demanding academic performance expected from them. The third reported item was the requirement of using Korean language both in daily life and in academic activities. Other reported difficulties were: the sense of isolation, the cultural shock, dietary differences, and the required use of English. These latter items were considered less challenging.

FIGURE 4. Level of Difficulty Overtaken during the Study Program (descending order from more to less difficult)



These findings are consistent with the some of the drivers, which motivated the mobilized students to apply for the SENACYT-KHY scholarship program. Access to better practices in research required long hours dedicated to laboratory work, and the academic performance standards of the subjects studied were demanding.

What are the benefits and potential risks of international mobility as a mechanism to build S&T human capacity in the context of the brain-drain/brain-circulation debate?

6.7. Benefits

Outcomes and Impact of the Program

Although the main goal of the present research was not to conduct an evaluation, the collected data was important to examine the outcomes and impact of the SENACYT-KHU Science and Technology Program between 2009-2015. Frequently, these two categories (outcomes and impacts) are confused and difficult to be measured. In this research, the authors consider the outcomes of those results as short-term and medium-term effects of the intervention. The program also left long-lasting impact for the human S&T capacity building in Guatemala.

Outcomes of the Program

Respondents were asked to provide details on their academic production directly attributed to their program at Kyung Hee University. Considering the diversity of the scientific and research field, the various levels of study among the respondents (undergraduate, master, combined and doctoral programs) and the possible external factors influencing their academic/research production, the purpose of the related items in the data collection instrument was to gather evidence on the yield of their research activities. Quality of the production (impact factor of the journals, citations, and H index) was beyond the scope of the purpose of this research. Table 9 provides a broad picture of the outcomes.

TABLE 9. Academic / Research Production – Scholarship Awardees

Academic/Research Production	Indicator
Publications in Peer-Reviewed Journals	85% of respondents declared having published between 1–5 publications
Other publications (academic essays, books, book chapters)	38% of respondents declared having published between 1–5 publications
Posters (this is not a traditional way of classifying research production – maybe you can use publications in academic events?	50% of respondents declared having published between 1–5 publications
Thesis / Dissertation	100% of respondents declared having finished or nearly finished a thesis or dissertation
Patents	13% of respondents declared having registered between 1–5 patents
Funding (grants, fellowships) (this is not “production” – I think this is important information, but maybe it can be presented separately	38% of respondents declared having obtained additional research funding
Participation in academic events (just participation or it includes presentation?)	100% of respondents declared having participated between 1–5 academic events (conference, seminar, congress, workshop)

Some of the explanatory comments provided by respondents are as follows:

“I was able to publish two journal papers during my master program. Also, I presented my research progress in two conferences. I think that without my study experience at Kyung

Hee University, I would have not registered academic production." [respondent No. 11]

"I had the opportunity to participate in six international conferences. In four of them, I attended as an author and in two as co-author. Besides, I participated in three local conferences. My laboratory included in the planning of activities, participation in at least one seminar per semester and one workshop per year" [respondent 14]

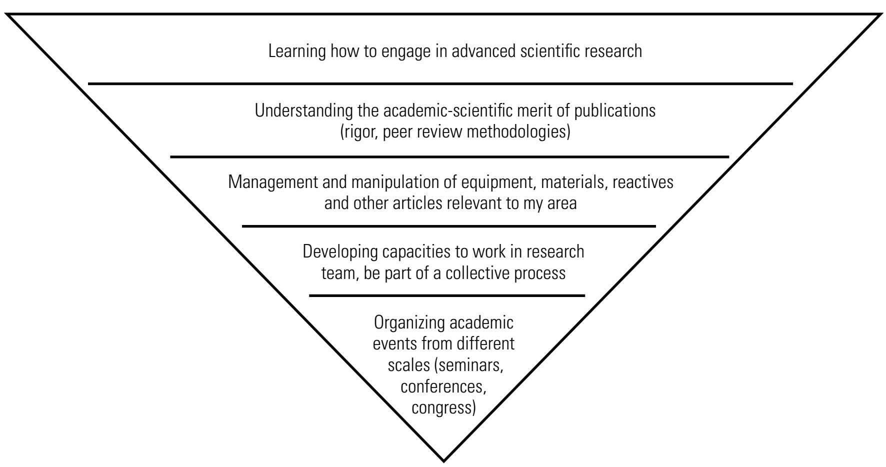
"To be honest, my laboratory was very competitive and pushed its members to aim at high impact factor journals and active pursuit of patent applications. In my case, I published three papers as a co-author. In addition, I participated in conferences with two posters and an oral presentation. My research results were included in three patent applications in the role of principal investigator. Finally, in collaboration with my research group we obtained three grants from different funding sources." [respondent 22]

Impact of the Program

The indicators may be difficult to capture the impact of the program at this moment because the participants graduated recently and some students have yet to complete the program. As the indicators of impact are better evidenced with time, we acknowledged this as a possible constraint in the limitation section of this study.

With this consideration, it was relevant to collect data on the acquisition/development of the research skills that are long-term, widespread positive changes produced by the intervention of the SENACYT-KHU cooperation program. The respondents provided their assessment on the acquisition/development of technical and scientific skills as a result of their experience in Korea.
Figure 5 presents a summary of the scientific, technical and research skills acquired or developed by the scholarship awardees organized in descending order according to the reported level of strength (depth).

FIGURE 5. Acquisition/ Development – Scientific -Technical-Research skills



Other suggested indicator of impact (recommended by the respondents) was their acquired/developed ability to participate and network with professors, researchers, scientists or industry workers in their field of study. Some of the responses include:

> "My research group was actively engaging in projects carried out along with private firms. This allowed me to participate in meetings and joint presentations. I was also invited to do an internship of nearly 8 months in which I interacted with researchers more connected with the industry." [respondent 2]

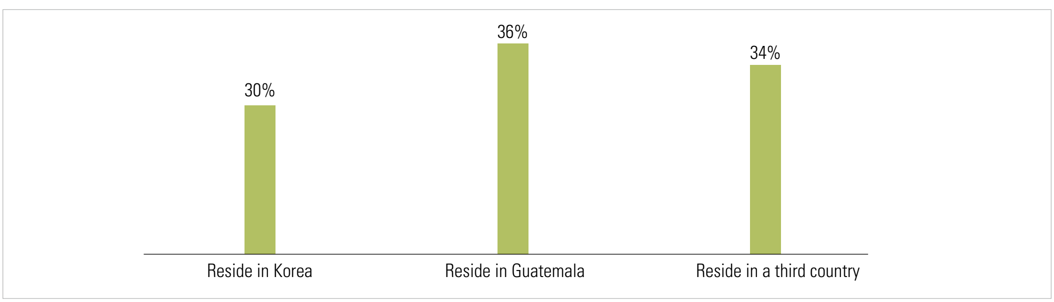
> "As part of my study experience at Kyung Hee University, I participated in collaborative research activities with researchers of the KU Leuven University from Belgium during the two years. This collaboration even led to two academic visits and participation in a joint international conference. " [respondent 6]

> "Biomedical Engineering is a field in which networking and collaboration are encouraged. I could participate in effective partnerships with researchers from other universities in Korea as well as from universities in the United States. Some collaborative activities were conducted along with researchers from the MIT (Massachusetts Institute of Technology) area of Global Health Informatics." [respondent 18]

6.8. Potential Risks - Brain Drain and Brain Circulation

This section aims at presenting and discussing the data collected from the respondents in the context of the brain drain/brain circulation dilemma. One of the relevant indicators researchers wanted to establish was the place of residence of the scholarship awardees. This sole information is insufficient to determine whether respondents changed their country of residence permanently or for immigration purposes. For example, in some cases, a significant number of respondents moved to a third country to continue pursuing advanced higher education studies after graduating from their respective study programs at Kyung Hee University. While Korea remains a temporary location for some students, as of February 25th, 2018, out of the 44 scholarship awardees, 16 now reside in Guatemala (36%), while 15 reside in a third country (34%), and 13 (30%) reside in the Republic of Korea.

FIGURE 6. Scholarship Awardees by Country of Residence, Feb. 25th. 2018



For the sake of data collection, respondents were separated into two groups: those whose current place of residence is in Guatemala (living and working in the country) and those whose current place of residence was abroad (either in Korea or a third country).
Table 10 summarizes the statements provided by the first group of respondents on the challenges facing their contributions to the development of science and technology capacities when living and working in Guatemala.

TABLE 10. Challenges and Opportunities to Contribute / Development of S&T when Residing in Guatemala

Challenges	Contributions
"It was difficult to find employment opportunities doing full-time research; I was told my qualifications exceeded the average expected formation. I had to accept a non-research position in a private firm."	"I am currently engaged in a project to promote scientific research, share my experience and use different methods to solve problems. I am currently implementing the launch of an open data portal, a key piece for scientific research since it provides data that allows for studies. Which I could not have done had I not acquired the necessary knowledge in Korea about the science of data."
"In the vast majority of Guatemalan companies and institutions, the academic degrees obtained abroad are not appreciated; therefore, it has not made the difference in my reincorporation to the employment in the country."	"Although I did not find a position as a full-time professor due to lack of academic career opportunities in Guatemala, I try to contribute through teaching activities in various higher education institutions."
"Lack of funding for research activities, if we want to engage in research projects, on many occasions we do so voluntarily, without proper economic compensation."	"I am a professor at the Graduate School of the Faculty of Engineering of the San Carlos of Guatemala University. I have contributed with the advising and development of graduation works focused on the resolution of relevant technological problems."

What policy implications can be drawn from the SENACYT-KHU Science and Technology scholarship experience?

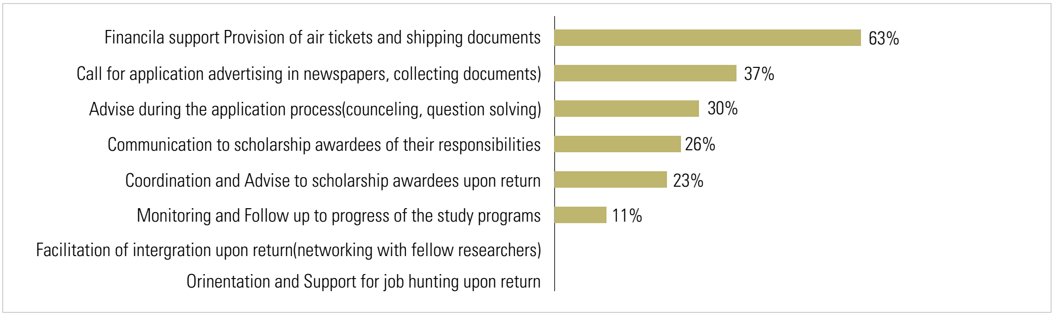
6.9. Policy Implications

The significance of contribution (support) by main actors / SENACYT-KHU Science and Technology Scholarship 2009-2015

S&T capacity building policy interventions have to be coherent, integrated, and sustained over time in order to produce efficient and effective outcomes and impact. However, Padilla-Perez and Gaudin (2014) have presented evidence of the fragmentation and short-term vision of most of STI policies in Central America, including the Republic of Guatemala. The present research asked scholarship awardees to assess the performance of the main parties responsible for the SENACYT-KHU Science and Technology Scholarship program, which were the Guatemala National Secretariat of Science and Technology –SENACYT and Kyung Hee University. In addition, they were asked about the complementary support provided by other stakeholders.

Figure 7 illustrates the assessment given by the scholarship awardees to the main contribution (support) provided by SENACYT. The highest level of contribution was assigned to the provision of round-trip air tickets for their mobilization Guatemala-Korea-Guatemala. The logistical arrangements created to handle the physical documents for their application was also assessed as a significant contribution. The follow-up and monitoring process to evaluate the student's progress in the program of study received a considerably lower assessment. Finally, the support provided by SENACYT upon return, either facilitating their integration to research/scientific networks or to guide their incorporation to the employment context, was assessed as nonexistent. While this was not a commitment which SENACYT engaged at the signing of the document, the respondents considered it an integral part of the policy.

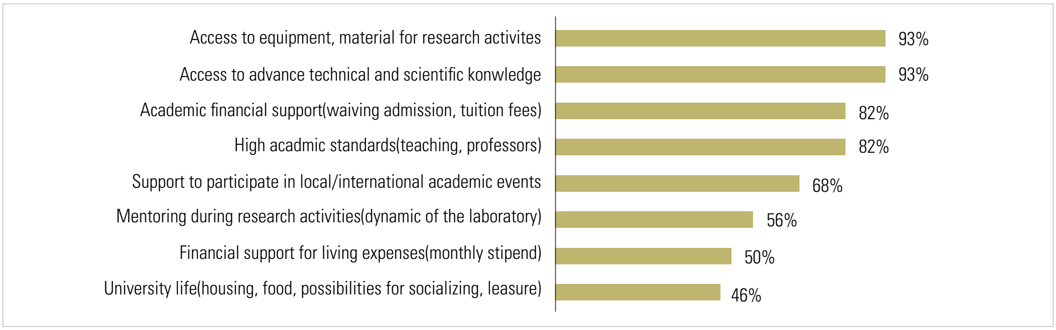
FIGURE 7. Perception of the Significance of Contribution (support): SENACYT



In the case of the perception of scholarship awardees regarding the contribution (support) provided by Kyung Hee University, Figure 7 shows the highest rating for two categories: the access to equipment, materials, and research activities and the access to advanced technical and scientific knowledge. This is decidedly illustrative of the program's main contribution in terms of science, technology, and research capacity development. Mobilized students valued these features of the program above other support than in their home country as such materials would not have been possible to access.

Perception of the importance of academic financial support comes next, along with high teaching standards. This does not mean scholarship awardees value these two items less. Nonetheless, they placed a higher emphasis on their own research and scientific contributions completed by Kyung Hee University as this has a higher impact on their careers.

FIGURE 8. Perception of Significance of Contribution (support): KHU



Overall, the signing of the agreement between Korea and Guatemala and its subsequent operationalization represent a learning experience in terms of S&T capacity building. On the one hand, talented Guatemalan students were provided with the opportunity to pursue higher education in different scientific areas at Kyung Hee University, an advanced level of programs that were not available at Guatemalan Universities.

Also, the involvement of an official institution on behalf of the Government of Guatemala, as is the case of SENACYT, was critical for the dissemination and promotion of the call for applications within the Guatemalan student community as well as its contribution to cover the expenses of air transport and mobilization of the scholarship awardees to the Republic of Korea. However, because this was the first registered experience with these characteristics, opportunities for improvement have been identified. In an evaluation by the Diplomatic Mission of Guatemala in Korea (Villagran, 2018), it was found that "despite the significance of signing of an S&T capacity building cooperation agreement, the language manages to capture the intention of the parties to develop a human resource training program and academic exchange; which only vaguely defines the specific obligations of the signatory parties." In the case of Kyung Hee University, the commitment was limited to offering scholarships for Guatemalan students without defining the details on the number of scholarships available, specifications of the coverage scope, and the commitment of continued support. For its part, the responsibilities of SENACYT were limited to the selection of candidates and the financing of round-trip air tickets for the favored students. In this case, a commitment of continuity in the time of the provision of said tickets was not specified either. The lack of definition within the framework of the signed agreement became evident in the fluctuation of the number of students who benefited per period of application (once per semester).

Other institutions, organizations, and actors with some degree of participation in the program referred by the respondents included the National Secretariat of Planning and Programming of the Presidency of Guatemala (SEGEPLAN), an institution in charge of coordinating efforts and support provided by international cooperation initiatives. Its main contribution was the dissemination of information regarding the call for application to the SENACYT-KHU Science and Technology Scholarship Program. A second organization mentioned by the several of respondents was the Institute for the Development of Higher Education in Guatemala (INDESGUA). This is a nonprofit organization that gave advice to some of the scholarship awardees on the application process, translation of documents, preparation of application package and communication with laboratories at the preliminary stage of application. Another entity was the Embassy of Guatemala in Korea. According to the students, their contribution consisted of services and attention provided to students during their time of residence in the Republic of Korea. Finally, another contributing element to the student's participation in the program was the support provided by senior scholarship awardees.

In order to draw policy implications and policy options, we use the analytical frame proposed by Gribble (2008) as the main focus of this article is placed in the perspective of the sending country, in this case, the Republic of Guatemala. Gribble (2008:28) proposed three policy options for managing international student migration: "Retain, return and engage".

a) Retain: the Domestic Supply Option

Guatemala requires a highly educated globally competent workforce. Taking advantage of the student mobilization, scientific collaboration, international cooperation, and several other factors are critical in order to catch-up and overcome the country's current stage of lagging behind. However, the main responsibility lies within the national spectrum of S&T public policy. Understanding the motivations, ambitions, and needs of individuals with the potential to engage or already involved in science, technology, and research activities in Guatemala is important for building a strong research environment locally. For this reason, the question proposed by Bonilla and Kwak (2014:18) is still relevant: "To what extent is the domestic higher education system of Guatemala able to produce highly educated human resources?" Based on the data collected in the present research, it appears that insufficient domestic supply of research-oriented higher education study option along with other domestic circumstances might be leading to the outflow of talented and promising talented students. In view of this scenario, Gribble (2008:28) sustained that if the "sending countries are able to address these key issues then they would be more likely to succeed in containing any student brain drain that may be taking place." Reform, expansion and strengthening higher education are pending and urgent tasks for Guatemala.

b) Return: the Repatriation Option

Also, the return option has been known as part of repatriation policies promoted in relatively recent international experiences, mainly observed in a few East Asian countries such as the Republic of Korea and Taiwan. These two countries devoted specific policy incentives to attract their S&T human resources trained/educated overseas and motivate them to return. The case of Korea illustrates the connection between the return of a technical elite to the economic development and the development of an effective national research system. The Korean government increased support to Korean engineers and scientist to return for a certain period of time.

If the students after graduation intended to return home (eventually), it does not constitute brain drain and might be considered only a temporary migration. The migratory process counts on an infinite number of reasons for individuals to stay abroad, and, for this reason, it is also important to challenge the brain drain as a postulate of economic analysis.

Permanency and recurrence of international migration of students, intellectuals, scholars, and scientists through the ages is not a new phenomenon and is not likely to diminish but rather to intensify in the era of a globalized economy and a globalized labor market.

To retain, the nations must attract scholars and scientists by having good job positions available upon return. In terms of policy, this is similar to "retaining" since it implies the need of academic structure, but it also means that industry should be interested in highly qualified HR (which have to do with R&D and innovation incentives).

c) Engage: the Diaspora Option

Designing and implementing mechanisms to engage the Guatemala scientific and research diaspora is still an underexplored option, which could provide an effective scheme to mitigate (or reverse) the effects of brain drain. Known in the literature as the Diaspora Option (Gaillard and Gaillard, 1997; Gribble, 2008; Jacob and Meek, 2013; Meyer et al, 1997; Vessuri, 1996), as a policy option, this could provide opportunities for effective technology transfer and scientific/research collaboration with a positive impact on Guatemala. An interesting experience for turning the negative effects of emigration into potential benefits for the development of S&T activities is offered by Colombia as this country is known for promoting the circulation of students, scientists and technologists between Colombia and the rest of the world (Meyer et al., 1997). Known as the Caldas Network, this platform consists of Colombian researchers and professionals who live and work abroad. It was created as part of government policies formulated at the end of the 1990s to connect to the competence of expatriate intellectuals to the home country. The objective was to achieve "the participation by expatriate brains to the intellectual and cultural development of the country." (Granés, Morales and Meyer, 1996:1)

As for the case of Guatemala, the International Network of Guatemalan Scientists (RedCTI) was founded. This initiative commenced with the support of the Guatemala National Council for Science and Technology (CONCYT) in July 2005. A group of Guatemalan scientists dedicated to teaching, research and technology development in various institutions in Guatemala created a periodic gathering called CONVERCIENCIA [convergence of science]. This gathering "constitutes an encounter of Guatemalan researchers residing abroad with their fellow scientists and researchers located in Guatemala, with the purpose of promoting interaction and professional collaboration among peers." (RedCTI, 2005) They seek to foster contact and exchange among scholars with permanent residency in Guatemala, as well as their peers working and engaging in scientific activities overseas.

RedCTI and CONVERCIENCIA have remained active with intense fluctuations over the years. Formally, RedCTI has issued internal regulations and created stable mechanisms to attract further members; however, changes in the National Secretariat of Science and Technology leadership (particularly during the period 2012-2015) discontinued the operation of these channels. Since its creation, RedCTI has barely accumulated 130 official members (RedCTI, 2018) in 13 years. Admittedly, the number of Guatemalan scientists and researchers has proven to be significantly larger than the one represented in RedCTI, those individuals remain connected through informal channels of communication (mainly social networks) with only superficial of interactions. Further research should be devoted to exploring the dynamics and results of the RedCTI alternative.

7. CONCLUSIONS AND LIMITATIONS

7.1. Conclusions

Science, technology, and research capacities in Guatemala, in particular the human capacity, present a complex landscape. Both input (number of researchers, the formation of highly skilled/educated human resources in local institutions, investment in higher education, and R&D activities) and output (number of scientific publications, and patents) indicators are evidence of such a situation. Moreover, weak institutions and incipient S&T public policies offer a pessimistic perspective for this developing country to overcome the several barriers perpetuating the backwardness trend. In this context, international cooperation offers meaningful opportunities for S&T advanced countries, such as the Republic of Korea, to engage in partnerships with Guatemala and contribute to the process of building S&T capacities.

A mechanism such as student mobility offers both significant benefits for the S&T capacity building process in developing countries, in this case Guatemala, as well as risks in the context of the brain drain/brain circulation paradox. For this reason, international cooperation efforts ought to be framed in long-term, integral and cohesive national policies that could take into consideration the several moments the mechanism involves: the prospection of S&T human capacities to be developed, the unfolding of the study programs of the mobilized students overseas, and the return of the graduates and their effective reincorporation in the local work context.

Admittedly, the occurrence of brain drains (understood as permanent emigration) is a risk for developing countries facing in their path the training and educating the human capital abroad. However, different policy options and policy instruments can not only mitigate the effects of brain drain and turn it into brain circulation, but also promote measures to prevent the loss of highly educated human resources. The core idea strives on the responsibility of policy makers and leaders to design cohesive S&T capacity development intervention as parts of concerted national efforts.

In the case of the SENACYT-KHU Science and Technology Scholarship Program that implemented student mobility from Guatemala to the Republic of Korea between 2009–2015, these results document an optimistic scenario as indicators of outcomes and impact have proven to be positive. The objective of building Guatemalan S&T human capacity was achieved. Nevertheless, based on the analysis of the collected data from the scholarship awardees, the risk of a significant number of graduates to relocate their place of residence in a different country is latent due to considerable challenges faced upon return. For these reasons, Guatemala requires a stable, effective, and long-term national S&T national policy that can to coordinate and absorb the valuable cooperation provided by partner countries and international higher education institutions.

Nations, particularly those in the path towards development, need to have a clear understanding of the S&T human capacity they can count on. If forming and accumulating scientific and research human capacity is such an expensive and time-consuming endeavor, the first step those societies have to take is to devise a clear map between the areas in which their nationals are well-trained and highly skilled, and those requiring priority S&T capacity building intervention. A significant challenge is faced by those building S&T capacities in terms of building meaningful S&T capacity for sustainable development. In other words, it is not only important to build capacity but to create the relevant capacities for the stage of development of the partner country. The present research, based on the discussion of the brain-drain/brain circulation dilemma, focuses on the possible policy implications of student mobility for S&T human capacity development.

7.2. Limitations

The researchers understand that the present studies observe a set of limitations that should be considered in possible future studies. On one hand, the period of cases studies, 2009–2015, is still quite recent. This factor might limit the discussion of possible brain drain in which Guatemala loses its valuable, highly skilled human resources educated through S&T international cooperation intervention. As such, further research is recommended in the coming years.

Second, the application of a qualitative research methodology could restrict the extraction of generalizable conclusions. However, the data collection was comprehensive and rigorous, which resulted in valuable data that shed light over an under-researched topic, which is student mobility as an S&T capacity building mechanism in Guatemala. Further empirical inquiries are also suggested in order to contribute to the creation of a body of literature addressing S&T capacity building policies from the viewpoint of developing countries.

Finally, the research addressing the impact of mobility from the perspective of the developed (host) country could shed light on mobility as S&T international cooperation mobility from a different stance. In this particular case, it would be interesting to research the outcomes and impact of the program for the Republic of Korea.

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