Final Draft – GRC Discussion Paper:

The Science and Technology Workforce Development

A world in transformation

The world today is experiencing structural global transformations, many of which can be attributed to the fast pace of scientific discovery, development and innovation that has occurred in recent decades. Science and technology (S&T) are viewed not only as a path to address complex societal challenges, but as critical underpinnings of economic advancement. For many nations, the need to develop a strong S&T workforce is a major priority to ensure growth and vitality of their economies. The UNESCO Science Report 2020 (UNESCO, 2021) highlights the varied levels of science development across the world, recognizing the differences between developed and developing countries in the science enterprise. Countries also vary in their capabilities to apply technological development and innovation to improve the living conditions of their societies.

While S&T has been key for economic growth and prosperity in many countries, others have recognized that S&T alone cannot bring about full prosperity without the parallel development of the social sciences and humanities. The complementarity of S&T and the social sciences and humanities for development has been studied for some time (Steward-Gambino and Rossmann 2015). It is argued that in the United States that the role of STEM has been key to innovation and global competitiveness and that higher education is considered vital for preparing future leaders. But, despite this importance, a prevailing view is that education must be extended to prepare a broadly informed citizenry in order for the country to meet the technical challenges of modernity and to maintain its democratic leadership in the world.

Scientific and societal change has also impacted how science is conducted. The sheer scope of societal problems that transcend national borders, and the scale of resources required to address them, have pushed disciplinary boundaries of scientific disciplines and underscored the importance of cross-disciplinary approaches. Interdisciplinary science has catalyzed new research areas and achieved previously unreachable solutions.

New challenges have also underscored the need for broader approaches encompassing international partnerships to take on global challenges such as those identified in the UN Sustainable Development Goals, and currently illustrated globally by the ongoing COVID pandemic.

Societal and technologies changes have also impacted how scientific research can be conducted. For example, the decreasing cost of technologies and options for increased mobility have lifted constraints on where researchers can work, considerably broadening the physical boundaries of the S&T research ecosystem. Increased mobility of S&T human capital may benefit scientific research overall, but pose challenges for nations that suffer "brain drain" because fundamental research infrastructure development including robust educational systems take time to build.

The S&T research enterprise requires a workforce with differing levels of S&T education and skills that include technical training and high-level skill formation. This includes the role played by business in implementing training policies that will improve S&T capabilities within their industries. The globalized nature of many industries, coupled with advances in computing and technology, and the changing conceptions of work and workplaces, will continue to produce new occupations and jobs that in turn spur the constant refreshing of skills. In addition, the scope and scale of research ecosystems vary across nations, reflecting different levels of scientific establishment as well as different national interests and needs.

To build and expand a strong S&T workforce, nations must weigh needs for investment priorities across different sectors and interests. These considerations can be viewed as both needs and challenges for nations and governments, presenting a varying spectrum of investment priorities across different nations. However, some needs are foundational, without which a path forward is not possible. Nations would benefit from considering the following factors as they pursue S&T workforces for the future. An international view of needs and responses can be strategically built by considering the present on-going global transformations.

Research funding councils have a key role to play in developing the S&T workforce at both national and global levels. Funding councils are instrumental in supporting the education and training of scientists and engineers, in focusing the direction of research in and across disciplines, and in promoting international collaboration to tackle problems such as climate change where individual countries cannot alone find solutions.

They also play a critical role in advising governments on the importance of investing in all levels of the S&T workforce, to catalyze positive impacts on national and global economies. Funding agencies and councils can develop programs and policies that support effective paths to vibrant S&T workforces a cross scientific disciplines and career types, inclusive of diverse communities. Funding agencies can find ways to facilitate partnership development among key stakeholders in the public, private, and academic sectors, and work with leaders to attract talent to S&T careers.

One of the major challenges for funding agencies and policymakers is to closely interact in order to facilitate collaboration among public, private, and educational sectors toward the common goal of an S&T capable workforce. Synergy among these stakeholders could amplify coordinated efforts to achieve greater progress toward a vibrant, multifaceted research ecosystem.

The challenge for the Global Research Council is to navigate an inclusive path where nations of varying sizes and levels of research establishment can chart their own course in the enormous and complex ecosystem of S&T human capital development. The GRC can also provide insight to their respective communities that S&T and humanities and the arts not only contribute to the strength of a nation, but they contribute to strengthen each other. Here, then, is a key question to research councils, how to finance both sciences and humanities? How to prioritize in front of shortages of funds? How to contribute

to the better definition policies underpinning both STEM and the social sciences and humanities? The GRC is well placed to deal with these issues.

Science and Technology workforce development

S&T Education, Training, and Career Paths

Critical to all sectors of a strong S&T workforce is robust education and training, with clear paths to diverse careers within the S&T research enterprise. STEM education and training is prerequisite to the strong tertiary education and postgraduate training that research careers require.

Education and training of the S&T workforce is broad and complex, with multiple roles and contributions from education, government, academia, and the private sector. Funding agencies and research councils can play a pivotal role in offering guidance to policymakers, as well as providing programs that can have catalytic and multiplicative effects, particularly on the academic career path on which most councils focus.

Funding agencies and councils are focused primarily on the S&T workforce at tertiary and postgraduate levels, and the continuing career paths through the academic and other employment sectors. This is where GRC partners can have profound impact on S&T workforce development.

At the earliest educational levels, perceptions of S&T and STEM careers could be enhanced, incorporating the participation of teachers and parents. Providing greater access to professional learning in specific STEM disciplines, cross-curricular pedagogies, real-world problem-based learning, future careers, and industry requirements, and identifying and disseminating best practice in teaching and learning will ensure that teachers have the capacity and confidence to facilitate deep learning of S&T. Further, teachers should be provided the means and training to demonstrate the importance of S&T to everyday life and future careers, which would engage and assist parents to encourage their children to pursue S&T.

The focus on early levels would also ensure that diversity, equity, and inclusion are incorporated early in S&T education and training, to illustrate that S&T careers are open and accessible to all.

The 2013 GRC Statement of Approaches on Building Research and Education Capacity laid out challenges for nations of differing economies and research infrastructures in building S&T capacity, and offered principles and actions for GRC partners to address such challenges. These included equal partnerships among global collaborators, sharing good practices in research management to promote institutional capacity building, and to sustain a pipeline of diverse researchers and educators by funding across the research pipeline.

For inclusive S&T workforce development, funding agencies can provide funding opportunities to young researchers and communities traditionally underrepresented in S&T, as well as working to reconfigure the academic career paths to remove obstacles that prevent full participation of all communities. Sustainable funding instruments such as fellowship and professional development programs at all stages of careers can serve to recruit and retain researchers of all levels.

Diversity, Equity, and Inclusion

An equally foundational issue is that of diversity, equity, and inclusion. Diversity may refer to different communities, including gender, race, ethnicity, and economic status. Diversity can also reflect differing national interests in areas of S&T, diversity of skill levels, and diversity of career paths, to pave a path to a S&T workforce with strength at multiple levels. It is important to recognize that national interests and needs in the S&T workforce are as diverse as their territorial needs. Investment in diverse skill levels and career paths can help to mitigate the risks of uneven workforce development focused on a very specific career sector or field, which may be vulnerable to rapidly-evolving technologies and global markets.

In this sense, industry (private sector) involvement is critical. While there is still work to be done to help industries and professional associations to better identify and outline their workforce requirements for high and mid-level S&T skills training, industries are often able to identify their immediate needs, and some capacity building schemes can be rapidly implemented to supply such a STEM-capable workforce. The implementation of public policies can positively impact their ability to develop and implement longer term perspective of skills that will be or might be required in specific industries. For example, the time frame required to build capable workforce that includes high-level STEM skills such as required for scientific research or engineering, as well as technicians and technologists required to support them, ranges around a decade. [1]

Other important aspects to consider when dealing with skill building revolve around STEM skills that lead to a workforce capable of solving problems, thinking critically, innovate and implement and develop new technologies. This last is especially important considering the tendency to rapid change in technological fields and the automation of multiple non-technological industries. The impact of such changes, inevitably alter the human resources demand and countries need to be prepared to have a workforce with some level of STEM skills even if they are not specifically in STEM related areas.

Diversity also calls for national economies to benefit from the contributions of productive members of society, and increasing the numbers of such members could provide concomitant increased benefits. Investing in inclusive workforce development across diverse communities including race, ethnicity, gender, and economic status, can lead to better economic outcomes overall, and reduce inequities.

The underrepresentation of women, indigenous peoples, low socio-economic groups is evident not only in the STEM Workforce, but also visible very early in their involvement in the study of STEM subjects in primary education.

Gender

As noted by many researchers, the advancement of women in science and engineering is very slow. Sciences and engineering are highly gender segregated, both horizontal segregation between disciplines and vertical segregation between levels. Women choose less the domain of science and engineering and within all science domains the rate of females in senior positions is substantial lower than among doctorate students and junior positions. There are two types of explanations, the leaky pipeline and the

glass ceiling. The leaky pipeline refers to the tendency of women scientists to leave the academic sector in the course of their careers.

The 'glass ceiling' reduces the proportion of women at the higher levels of the career hierarchy. Organisational and cultural barriers in the academic system may prevent women from career advancement. Female scientists more often mobilized a more collective model than men. However, evaluation procedures focus on the individual, which is more favoured by men. It is found that female scientists tend to have somewhat more collaborators than male. Women motivate their collaboration primarily with “mentoring” strategies, whereas men also tend to use "instrumental," and "experience" strategies. Studies also show the added value of the increase of women in science and engineering to the way researchers engage in interdisciplinary cross-fertilization, team-collaboration, field-creation, and problem-orientation.

In addition to gender, ethnic diversity has introduced different views into the Eurocentric knowledge perspective, inducing self-criticism and the awareness of the necessity of enlarging the scientific field to other cultures. The previously referenced study discusses a study on the female domination of computer science in Malaysia, also a critique of a western bias in gender and technology studies, advocating more context sensitivity and focus on the cultural embedding of gender and technology relations. The impact of digitalization and virtualization of science practices on gender dynamics in science practices is relatively still a terra incognita. Another issue to be further explored is the impact of gender as conceptual research tool may impact on scientific knowledge and innovation.

Challenges for GRC

A strong S&T ecosystem encourages schools, employers, and non-profits to work together to ensure that students graduate with both the technical and personal professional skills they need. The GRC can advise policymakers on the need to incentivize companies to invest in innovation and create promising new job opportunities for these graduates.

Funding councils can also help policymakers recognize the importance of focusing on research and innovation from different perspectives, that attract investment or incentivize local industries to do more research. Through these efforts, graduates from S&T areas can find new job opportunities, preventing “brain drain” and sustainably accelerating each country into a knowledge-based economy.

In this regard, it is important for each country to be clear on the sectors that give them competitive advantages, to focus their efforts on these sectors.

Having a global approach to developing the S&T workforce is crucial to overcome the challenges inherent in building one. Sharing best practices and successful cases in different regions and different scenarios can help funding agencies attain a better understanding of the steps and actions needed to bridge the gaps between demand and availability in the S&T workforce.

This could also help to mitigate the Global STEM Paradox. While education in STEM subjects has been recognized as a critical global need, many countries around the world are also facing increasing employment gaps in these fields. Key issues to resolve this paradox may be that market is not designed to send effective signals to the various actors (students, workers, employers and governments), to allocate the required funds for skill developments.

Working in concert with global partners, funding councils can advise on developing flexible policies capable of evolving and adapting to the changing requirements of the S&T ecosystem that accommodates national interests while embracing technological advancements.

Successful Strategies for GRC Partners

Funding agencies and councils can adopt a number of approaches to bring together the interests of government, industry, and education to achieve a skilled S&T workforce, emphasizing the need for continued training and reskilling to maintain a vibrant workforce.

One approach is to conduct S&T workforce analysis and forecast future S&T skills requirements, sharing findings across all sectors. S&T-related growth industries can be identified to under the impact of technologies on future work, and the resulting skills requirements. There is a need to improve data sharing across industries, sectors, and portfolios to support decision-making.

Another is to encourage effective industry engagement with educational and research institutions to enhance professional learning, develop real-world problem-solving experiences, and promote awareness of S&T careers.

Initiatives such as internships, work integrated learning, field-work and industry mentoring programs enable students to understand the portability of their skills and the array of career opportunities available.

Case Studies: Successful Strategies and Programs

The GRC could gather and publicize strategies, case studies, and examples of programs that have been successful in achieving strong and sustainable S&T workforces in the respective countries. Such programs may serve as models or templates for partner councils to adopt and adapt as necessary for their specific needs.

The world needs sustained collaboration to develop robust S&T workforces, national and international, to tackle the increasing challenges faced by all nations. The GRC can make a unique contribution to finding global solutions by disseminating partner councils' experience-based knowledge of successful programs and strategies.

Panama: Gender Case Study

A case study performed in Panama (SENACYT-PNUD, 2018), corroborated the "scissors effect" of gender distribution on research activities along an ongoing timeline. The effect indicates that women represent the larger percentage of students enrolled in higher education. However, further along educational and career paths, they account for barely half of the researchers, scientists, and technicians in the country in comparison to their male counterparts.

Some of the main findings of this study show that there is an existence of gender gaps as well as ethnic groups gaps in the exercise of basic rights of women, such as the right to sexual health, reproductive life, a life without violence and political participation. The indicators analyzed show that, despite women having good health indicators, it is specifically in the sexual and reproductive health where they find main deficits of the right to health. The high maternal mortality and early motherhood in Panama, place the country in a low position in the human development index considering the gender inequality.

Women encounter greater obstacles than men throughout their scientific careers and participate little in decision-making positions of the knowledge society in Panama. In the dimension of "knowledge economy" women have been the majority (59%) holding professional and technical positions, with a clear tendency of increase in the last twelve years. On the other hand, women hold 40% of the positions in top and middle management. Although improvement has been observed in the last decade, there are still important differences by field and level. In some of the scientific fields, especially in areas such as physical sciences, mathematic and statistics, as well as computer science and engineering, and the fields of industry, production, architecture, and construction, the traditional gender division is maintained. It is notable that even though women graduate from the University more than men representing around 65% of the total, men still represent the majority of graduates in the traditionally male fields. Most of the country´s researchers are men (more than 60%).

Additionally, there is a hierarchic tendency: the advantage of men is superior in the positions of researcher than in the positions of support personnel or personnel of scientific service and technician. A metaphor frequently used to explain the fact that women are underrepresented in STEM careers is the "leaky pipeline". Although girls perform as well as or better than boys in math and science at the primary and secondary levels, they are underrepresented in some STEM subjects, particularly engineering and computer science, at the tertiary level.

Multiple overlapping dimensions that interact in complex ways also have an influence on women´s education, employment, and progression in STEM careers.

Questions for Discussion

1) What is the role of research councils in the development of an S&T workforce, how can these councils interact with universities and other knowledge institutions?

2) How would you define/frame the challenges to achieving a broad S&T workforce in your country? What are the barriers?

3) How are funding agencies promoting diversity and inclusion in the STEM workforce regarding gender, economic status, and ethnicity?

4) How can research funding agencies build national capacity while balancing the need to build global collaboration?

5) What are policy and strategic approaches to creating more public-private partnerships to develop a vibrant S&T workforce?

6) How do funding agencies demonstrate the benefits and impact of investment in S&T workforce education, nationally, as well as globally?

Overarching Considerations

1) Nations' interests in addressing national needs and challenges must be recognized while pursuing the global interest in building an S&T workforce. The global interest can be defined as the pursuance of a sustainable world as called for in the Sustainable Development Objectives.

DRAFT Principles

1) A broad, vibrant, diverse, and inclusive S&T workforce at all skill levels is critical to national and global research ecosystems, as well as national and global economies

2) Research funding councils should adapt, catalyze, and advise key stakeholders across sectors to develop an S&T workforce that has strength at multiple levels

Key Points

- Developing skills in critical fields
- S&T workforce strategy and challenges
- Integrating skills development for sustained growth
- S&T workforce education
- Adaptation to changes the science and technology workforce in a global context
- Public Policies to improves the development of the science and technology workforce
- Synergy within key actors (academia, government, public sector, NGO's)

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