Global STEM: Opportunities and Challenges

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ABSTRACT

The need for Science, Technology, Engineering and Mathematics (STEM) literacy extends beyond the boundaries of the major developed economies. The lack of wide reaching STEM literacy in the Countries with Less Economic Resources (CLER) is caused, and indeed compounded, by the lack of STEM economy in those countries. Here CLER is used as an umbrella acronym for the ‘Least Developed Countries’ and the lower tier ‘Developing Countries’ according to the United Nations (UN) economic classifications. Any STEM workforce development in a country without a foundation in the STEM economy would simply feed those countries (through immigration) where STEM jobs are located and in abundance. This flight of talent is known as ‘brain drain’. Tragically, this has manifested itself into a ‘feast’ or ‘famine’ situation for countries seeking economic prosperity. Whereas the major developed economies are feasting on STEM-based economic prosperity and growth, CLER is seemingly in perpetual famine state. On an intellectual level, the ethical approach to STEM education and literacy, in the countries with abundant economic resources must be designed to cross national boundaries and devote special attention and resources to those in the global village that are in the famine state, i.e., the CLER. In the absence of external stimulus, however the famine states, for the most part, would not be in the position to self-correct and thus the economic divide and injustice would continue to deepen.
1. RESEARCH PROBLEM STATEMENT
Develop the structure of a STEM-based economic prosperity model that holds the promise of reversing
the trend in deepening economic divide on the global scale.

2. RESEARCH METHODS
We first conduct a brief background study on the causes of economic divide on a global scale and
then formulate/forward three hypotheses that may be used as the framework to advance the research
problem.

Twenty-first century economies are invariably driven by technology. The cornerstone of modern
technology is the IT revolution. However, the IT revolution stands on the shoulders of industrial
revolution of the 18th century Europe in building economies. Modern machine manufacturing helped
improve the quality of life for the masses and gave birth to civil, i.e., democratic, society. The economic
divide is largely created between those countries that experienced industrial revolution and those that
did not. Since the foundation of IT is STEM, we may hypothesize that promoting STEM literacy in the
developing countries should, in principle, help their economic status and wellbeing. Although this
hypothesis proves to be a necessary condition for economic growth, it shall fall short of being
sufficient. The second hypothesis provides for the missing link to sustained economic growth and the
sufficient condition for global STEM literacy, namely creation of the STEM-based economy. We find
support for the second hypothesis in the goals of STEM literacy, which in the context of economic
development, is to develop a workforce with critical-thinking skills that is capable of formulating
innovative solutions to complex scientific and engineering problems. However implicit in this goal is
the existence of jobs in STEM disciplines, and hence the need for STEM economy. The third hypothesis
identifies the creation of civil societies, in CLER, as a necessary condition for sustainable economic
development.

We have identified at least three dimensions of this problem, namely STEM needs to go global,
STEM-based economy in CLER needs to be developed, and finally, pathways to civil society need to be
established. Within this framework, we propose the creation of an independent and dedicated Global
STEM Society. To foster the goals of Global STEM (called GSTEM for brevity), the proposed Society will
be a focused, non-governmental, non-profit action-organization. The primary goals of this action-
organization are universal in all STEM literacy projects, which we briefly review here. These goals are:

1. To help build the human capital, workforce development, in STEM fields
2. Develop knowledge-based workplace
3. Develop interdisciplinary thinking
4. Promote creativity and innovation
5. Develop problem-solving skills

In section 3, we present the educational content, method of delivery and address the structure of this
organization. Here we have formulated a new Grand Challenge in addition to the list of 14 proposed by
the Committee of the U.S. National Academy of Engineering. The 15th Grand Challenge that we propose
is thus ‘Global Engagement in STEM Prosperity’.

3. A NEW GRAND CHALLENGE: GLOBAL ENGAGEMENT IN STEM PROSPERITY
Before we can even address Global Engagement, i.e., the engagement of CLER with the technologically
advanced countries, we have to place them in their own context with regard to STEM. For example,
STEM literacy in technologically advanced societies is now so sophisticated that Kindergarten through
12, known as K-12, is now subdivided into Pre-Kindergarten to 4, 5 to 8, and 9 to 12. So symbolically
and indeed contextually, we are looking at K-12 education through the lens of PK-4, 5-8 and 9-12.
In contrast, there are hardly any examples of “P”, as in Pre-Kindergarten in CLER. There is no “P”
because the population is facing their own crises in basic human needs, namely health, clean water,
food, shelter, energy and sustainable environment. Now, add to their basic human needs their
conflicts and struggles with basic human rights issues and possibly violence against children, then we
can reluctantly and sadly conclude that Pre-kindergarten is indeed a luxury that most of the countries
in CLER are not afforded. The challenge of GSTEM Society is to reach the population in CLER, at all age
levels, and deliver the educational content that is suitable to STEM literacy. For practical reasons in the
current study, we have divided the educational content delivery in GSTEM into K-12 followed by the post-secondary, i.e., higher education, segments.

3.1. GSTEM in K-12: Use Western resources with a hefty dose of cultural sensitivity
For K-12, the first step is to adapt/transition the existing online STEM resources in technologically advanced countries into useable instructional modules for CLER. For this purpose two essential steps are needed: 1) Remove the language barrier, i.e., translate, and 2) Perform cultural sensitivity review, which is akin to the function of Institutional Review Boards (IRB) in the American universities. Both translation and cultural review are major undertakings. Indeed, the primary challenge in spreading GSTEM at the K-12 level in CLER by the technologically advanced countries is often the cultural divide that exists between them. In simple terms, population in CLER is often suspicious of the motivation behind such an outreach. How do we overcome, in some instances, the so-called “imperialist” image that finds its roots in world history? How do we show cultural understanding and sensitivity towards CLER? Obviously, the answer lies in working with/through local grassroots organizations and the local government. In addition and more importantly, as the religious issues have no place in STEM education, the instructional modules should avoid any reference or inferences to religions.

3.2. GSTEM in Higher Education: Capitalize on the Collaborative and Online Models
For post-secondary education, an expanding collaborative STEM education with technologically advanced countries offers a suitable model. This is essentially building on the existing ‘branch campus’ model that is widely used in the developing world. For example United Arab Emirates (UAE) hosts 35 branch campuses, Qatar boasts 12 international universities, China hosts 15 branch campuses and 52 U.S. universities operate 82 campuses in 37 countries. Although most of these joint ventures are market and revenue-driven; the ideal model should be need-driven. Indeed the majority of CLERs cannot support international institutions that require host country funding for their operation. However, we could still explore other options for content delivery in higher education, namely through MOOCs, i.e., Massive Open Online Courses that are free of charge. Although internet-based, online delivery of courses is not optimal in the pedagogical sense, but they could certainly serve our purpose where even a non-optimal solution is acceptable. Moreover, we need to infuse additional creativity and ‘out-of-the-box’ thinking in students of CLER than are normally embedded in their regular STEM courses. Fortunately, a storehouse of grand vision, innovative ideas and fascinating speeches is in TED Talks, which will play an important role in our Grand Challenge. We will continue to address the issue of funding in sections 4.3 and 4.4.

3.3. Organizational Structure of GSTEM: Promote Cross-Volunteerism
At the functional level, the GSTEM society needs: 1) Human capital, 2) STEM content and delivery system and 3) Operational funding. The GSTEM Society is a volunteer-based service organization, similar to other international non-governmental organizations (INGO) for its workforce structure, e.g., UNICEF, Engineers without Borders, Doctors without Borders, Save the Children, Peace Corps, CARE, among others. Indeed the dedicated workforce of these organizations, as they share the same vision and conviction to help those in need, could serve as collaborators of GSTEM field workers. This cross-volunteerism concept is analogous to Joint Appointment practice in academia and shall be promoted in GSTEM Society.

The content delivery system to remote areas of the world requires mobile satellite internet equipment that provides access to high-speed data, voice and video. In addition, the classrooms need computers/laptops/tablets with wifi connectivity to internet. This is certainly realizable, as it matches the vision of affordable computers for masses that was originally expressed by Google and later developed into the One Laptop per Child organization with success. Here, the IT revolution is an enabler that provides the technology to accomplish this level of broadband connectivity at any location in the world. The STEM content developers in the U.S. range from NASA through its Educator Resource Center (ERC) and NASA Kids’ Club to LEGO Education and to Khan Academy, among others. The educational content is available and rich, but requires translation and possible adaptation due to cultural issues, as noted earlier.

Finally, the options for the operational funding of the educational mission of the Society need to be addressed. Traditionally, INGOs of humanitarian aid missions receive philanthropic as well as UN
support. A few examples of the private Foundations that support these causes are Bill and Melinda Gates, Carnegie, Kauffman, Kellogg, Alcoa and Hall Family as well as corporations such as Microsoft, Google, Apple, Boeing and LEGO Education, among many others. In addition to its fundraising and receiving support from private Foundations and Corporations as well as UN, the GSTEM Society has to demonstrate financial accountability through low overhead management, commitment to transparency, and good collaboration practices with other INGOs in the field that share the same vision to reduce parallel work and duplication. As the educational mission of the GSTEM Society is only one component of the organization, we need to address an economic development plan in STEM areas suited to CLER. We present the structure of an economic prosperity pyramid in section 4.4, as well as continuing our discussion of finances and create a GSTEM model for transformative global change.

3.4. GSTEM as Transformative Agent for Global Change

For the Global STEM movement to be transformative, it has to affect people’s lives and wellbeing in CLER, thereby the necessity for STEM-based economy as an integral part of the model. At the market level, the STEM economy will be competitive in the global marketplace, which then leads to economic prosperity. The agent for transformative global change is thus developing STEM economy in CLER. The current pedagogy calls for integrating the general education with STEM into an integrated foundation, which we have taken to form the base of the proposed economic prosperity pyramid (see Figure 1). The “critical layer” in this pyramid is the STEM Economy that is labeled with “critical mass”. The “critical mass” signifies the suite of STEM industries that is needed to sustain development and growth at the national level. The type and diversity of these STEM industries is indigenous, i.e., uniquely defined and adapted to each individual country through their geographic location, natural resources and their economic prosperity plan. Finally, at the top of this pyramid, we have the emergence of the modern civil society that is enabled or indeed empowered through general education, STEM literacy and economy. The three dimensions of GSTEM Society are now the building blocks of the economic prosperity pyramid.

![Figure 1. The model of integrated STEM into an economic prosperity pyramid.](image)

The challenge in establishing STEM-based economy in CLER is daunting. Some of the main hurdles are:

1. Lack of collective will
2. Political instability
3. Regional conflicts
4. Reluctance of CLER governments to engage with
   a. imperialist view of INGOs
   b. perceived cultural insensitivity
5. Insufficient funding on the global scale
6. Inequitable resource distribution
The pathway to overcome these hurdles is primarily in the management and structure of the GSTEM Society. The United Nations needs to be in control and manage the organization. Philanthropies need to invest in developing STEM economy and local grassroots involvement is needed to alleviate cultural insensitivities as well as building trust. As noted earlier, commitment to transparency and accountability need to be the hallmarks of the new organization, following the guidelines set by the International Aid Transparency Initiative.10

The current international financial institutions and global policymakers are the World Bank, International Monetary Fund (IMF), World Trade Organization (WTO) and World Economic Forum (WEF). Although these organizations help lend/finance/fund economic projects in 172 countries, they are by no means adequate for creating economic prosperity on a global scale. However, they should still play a critical role in supporting GSTEM Society. Due to immense size of the GSTEM undertaking, we have to search for additional financial resources.

According to the 2013 military/defense budgets data,11 1.747 \( \times 10^{12} \) USD, i.e., 1.747 trillion USD was spent in 2013. The top 10 countries alone spent $1,142B. The next 10 countries spent $194B. Let us propose the creation of a Global Prosperity Fund that UN shall administer and each member state contributes an amount proportional to its military spending. Indeed, the Global Prosperity Fund shall receive 1 penny for every dollar spent on military expenditure. With this aspiration realized, the Global Prosperity Fund will have $17.5B (in 2013 numbers) at its disposal, which yields on average $175M/country/year for the bottom 100 countries in CLER. To put the $17.5B revenue in perspective, we note that this fund is four times the 2013 UNICEF total funding resources that served 128 countries.2 Now, even if we expand the number of the countries in need to 172 (according to data obtained through WB’s Open Data Initiative12) the average support for these countries will be $100M/country/year, all from the Global Prosperity Fund, administered by UN. The amount of support that a country receives shall be based on the merits of its proposal and include factors such as its population as well as other economic performance indicators that would make the investments equitable and the accountability transparent.

3.5. Pathway to Civil Society

From the three hypotheses that formed the framework of GSTEM Society, pathway to civil society in CLER is by far the most challenging. The active presence of the international human rights organizations and their critical reporting, e.g., through Reporters without Borders, is only the first step. The second step calls for a more effective UN vigilance and involvement. Finally, the third step calls for a united front on the part of the major developed economies as well as other nations facing atrocities and human rights violations in any country, including CLER. The collective will and resolve in step number 3 is often lacking, among other inherent weaknesses in steps 1 and 2. Further discussions on social engineering and promoting civil discourse are highly specialized and are thus beyond the objectives of the present research.

SUMMARY

The 15th Grand Challenge for Engineering, i.e., Global Engagement in STEM Prosperity has proved to be even more daunting than the first 14 outlined by the Academy.1 The three pillars of the new GSTEM
Society are identified and can indeed be constructed through technology and collective will. We recognize that despite this framework, we have only outlined the solution to this Grand Challenge and, in essence, have allowed ourselves as engineers, to make an implausible dream possible.

Finally, we take some artistic liberty in creating Figure 2 that shows The GSTEM Society, with the International Space Station (ISS) as the symbol of international cooperation in science and the United Nations logo, which symbolizes nations united.

Acknowledgements

The financial support from the Sharp Educational Fund in Teaching Excellence, at the University of Kansas School of Engineering, is gratefully acknowledged and greatly appreciated.

REFERENCES