

Employing Learning Centers to Retain Intellectual Assets for Marginalized Communities

Jennifer Fleming

School of Business, Purdue University Global, West Lafayette, Indiana, USA
Email: flemingjennifer7@gmail.com

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Abstract

The COVID-19 pandemic exposed the challenges and limitations of marginalized communities worldwide. This theoretical study focuses on identifying the trends in STEM education to develop a standard of learning centers to help small communities stop the perpetual losses in intellectual assets as their scholars migrate to other countries for higher education opportunities. The article uses a mixed methods approach to reveal the root cause of the absence of STEM circles in these environments and identify potential solutions to improve educational outcomes that support greater independence and economic stability. The literary review introduces the fundamental principles and skill sets needed within these marginalized communities' workforce to support the development of tools and techniques to avert the issues experienced in past pandemics like COVID-19. Four different case studies were conducted in North America, South America, Eurasia, and Africa to assess educational readiness and strategies for improving preparedness in science and technology. The research concludes with recommendations for developing international learning communities as a tool for resolving the loss of valuable intellectual property in foreign-born scholars that migrate to other geographies for advanced study by reintegrating them into their respective countries in periodic intervals to design, direct, and manage the dispersion of knowledge toward a more sustainable environment.

Keywords

Pandemics, Education, STEM, Learning Centers, Disability

1. Introduction

Society harbors many instances where a “narrowed” vision of a person or entity is unjustly deemed of lesser value, particularly when we don't understand the

subject. (Bain, 2004) reveals how *limited, external, and opposing* forces of an “originating” population can influence other “receiving” populations into believing the limits of the originator’s projected capability. This type of mental marring is hazardous in society because it can profoundly affect the aspiration, motivation, and accomplishment of entire generations, creating significant gaps in education, economic stability, and societal acceptance. Evidence of this phenomenon was witnessed in various countries’ preparedness when coronavirus outbreaked in Wuhan, China, and spread to become a massive event recognized as COVID-19, as characterized by the World Health Organization, which lasted from December 2019 to May 2023. COVID-19 provided a profound insight into the lack of preparedness in many countries, revealing deficiencies in educational systems, emergency readiness, and logistics management. This article analyzes the educational requirements (foundational knowledge) required in various global communities towards emergency preparedness in an effort to transform marginalized communities into areas of STEM education and research programs toward greater adoption, preparedness, and economic stability.

2. Foundational Knowledge

Marginalization is identified and defined by the characteristics under the seven federal-protected classes: race, color, religion, national origin, sex, disability, and familial status (Title VII, 1991). The National Collaborating Center for Determinants of Health defines marginalized populations as “groups and communities that experience discrimination and exclusion (social, political and economic) because of unequal power relationships across economic, political, social and cultural dimensions.” In its simplest form, we see these dynamics *first* manifest as mental models (Senge, 1990) publication, “*The art and practice of the learning organization.*” he notes, “Mental models are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action.” *Later*, we see how influencers of “mental models” and negative stereotypes threatened academic motivation and performance in marginalized students. This is further evidenced in 2005 research by Psychologists Steele, Aronson, and Steven Spencer, PhD, as they note, “it has become clear that negative stereotypes raise inhibiting doubts and high-pressure anxieties in a test-taker’s mind, resulting in the phenomenon of stereotype threat... which can threaten how students evaluate themselves, which then alters academic identity and intellectual performance” (Davies, Spencer, & Steele, 2005).

Unfortunately, the paradoxical belief that attaining popularity, celebrity, and excesses in economic status, philanthropic works, or scholastic aptitude determines a community’s (or individual’s) value. These historical perspectives enslave many marginalized countries into a false notion of anachronism that is difficult to overcome. Focusing on the tenets of scholastic aptitude reveals a broad spectrum of applications in deciphering and resolving the conditions that cultivate this marginalization. All evolutionary behavior hinges on the attainment of knowledge...

whether it originates from the discovery of fire, aeronautical flight, life-saving DNA research, or simply personal enhancement towards being one's best self. Therefore, our approach and attitude towards knowledge attainment can significantly differ and hinder our motivation towards performance standards.

All education is essential, regardless of its setting; this means our latter years can become as impactful as our formative ones. This discussion focuses on higher-education initiatives and the attainment of specialized skills in the areas of science, technology, engineering, and mathematics, also known as STEM. The background for this discussion is uniquely complex given the current set of world events: intense political campaigning, societal and economic unrest, and racial biases and unjust behaviors, in domestic and international countries. These were further compounded by a global pandemic (COVID-19) from 2019 through 2023; there could not be a more volatile time in history. Holding all other factors constant, we seek to address the issues of marginalization to avert preparedness issues resulting from pandemic events because all countries can only effectively contribute to this phenomenon if they are equitably skilled in science, technology, engineering, and math.

It is human nature to be a "survivalist", as evidenced by the theory of evolution (Darwin, 1859), so this pandemic offers a perfect palette for this demonstration. The absence of some countries in this fight to survive substantiates the prior issues of inequity in higher learning and industrial technology. Much of the work required to produce an acceptable medical antidote for COVID-19 required intense study, repetitive testing sequences, and operational excellence in science and bio-engineering. Therefore, the absence of such capabilities in many marginalized communities (i.e., in *formative and higher-education learning* settings) limited their ability to contribute to society. Unfortunately, areas of limited knowledge and negative stereotypes often foster considerable public mistrust and reduced contribution to scientific discovery. Greater and equitable participation in STEM academia worldwide can help reverse these negative stereotypes and low engagement trends. Any population lacking representation in these areas will become more susceptible to future scrutiny and anomalies threatening survival and continuity.

STEM was initially developed as a tool to bolster scholastic aptitude in areas of science and technology to ensure workforce availability (and technological capability) to support our industrial expansion and the nation's profitability. Since its original inception, we have noted additional considerations to "broaden the participation of underrepresented groups (i.e., women and girls) into STEM studies and careers" (Australian Council of Learned Academies, 2013). The International Monetary Fund (IMF) recognizes the highest-ranking countries in the world in nominal GDP: the United States has (GDP: 20.49 trillion) and China has (GDP: 13.4 trillion) with Japan, Germany, and United Kingdom rounding out the top five with (GDP: 4.97 trillion); (GDP: 4.00 trillion) and (GDP: 2.83 trillion) respectively (Statistics Times, 2020). So, we have approximately sixteen countries with

nominal GDP that exceeds 1 trillion; the next sixteen countries span just under 1 trillion to one-half trillion (half of which are split between Europe and Asia except for Argentina, which is in South America). Beyond that, the remaining 193 countries have GDPs spanning from \$414 billion (United Arab Emirates) to Tuvalu (Oceania), which is \$42 million (Statistics Times, 2020).

Therefore, our challenges exist in the missing elements, those countries that need structured programs toward excellence in science, technologies, and industrial (engineering) programs. Because these are the most vulnerable populations and the least represented, they have the greatest opportunity for *persistent* marginalization towards technological advancement and *perpetual* dependency on others for their survival. Now, we must take a methodical approach to this analysis, seeking balance in the assessment because evaluating those in the lowest tier is not practical because their most relevant issues may be survival-oriented, so higher education is not at the forefront of their primary needs. In contrast, those with a much higher economic status may be well-vested in their long-term planning to accomplish these goals. Moreover, we must consider the presence (or availability) of data from all affected communities to ascertain the current conditions, potential for instructional integration, and program success.

3. Literary Review

Before STEM education (science and technology), work experience, and leadership prowess are necessary to define and navigate the demands of a pandemic response, which will vary depending on each country's size, demographics, and technological footprint. However, there is one common denominator (dependent variable) among them: educational preparation. This begins with the availability (and capability) of strong educators to inspire, train, motivate, and encourage eligible students towards careers in STEM such that each region will have its own internal community of scholars ready to meet cultural and geographic-specific needs.

Recent research (Ersozlu & Barkatsas, 2024) into the psychology of STEM education reveals a series of theoretical perspectives spanning from teachers' social-emotional skills to the critical examination of assessment tools to develop proficiency and efficacy in research and development. **Figure 1** summarizes their findings and relevance to the advancement of STEM education.

Additional research is warranted to consider an independent variable (gender). In this case, Researchers D'Isanto et al. reveal the influences of gender in securing jobs, wages, and career progression for candidates for STEM employment (D'Isanto et al., 2021: p. 45). Their work concludes that men appear less encumbered by the time factors of fertility and duality in societal roles than their female counterparts. Other perspectives on this phenomenon are presented in the 2022 research of Quintero et al.; they posit that "regarding gender participation, men have a higher representation in STEM, despite the increase of interest of women in the last

Principle or Required Skill Sets	Value
Social-Emotional Skills (SEMS) of instructional community	Empirical evidence supports the purported role of teachers in the learning equation (Hattie, 2003), and points to teacher effectiveness, defined as the aggregated effects of a complex set of in-classroom teacher behaviors on student performance and learning (Seidel and Shavelson, 2007), as an important construct for optimizing learning processes (Scheirlinckx, J. et.al, 2023).
Knowledge Mapping Skills	STEM learning utilizes compounding effect, because the more we learn the more we contribute to the body of scientific discovery. Participation in new and existing research is analyzed using CiteSpace tool to reveal contributions at country levels (Yang, D. et.al., 2023)
Improving efficiency in learning via neuroscience techniques	STEM subject matter is complex and tedious at times, improved study techniques to avert procrastination and latency improves overall retention and performance (Cherrier, S. et.al., 2023).
Optimal student functioning through greater autonomy	Autonomously motivated students have often been associated with higher productiveness and willingness to put more effort into their assignments and learning activities...because a STEM researcher seeking to develop solution strategies in a pandemic setting needs to exert effort and persist towards medical achievement (Johansen, M.et.al., 2023)
Due diligence in instrumentation and assessment of laboratory tools	Experimental self-efficacy (ESE) encapsulates students' belief in their abilities to perform laboratory activities and can impact their motivation, goal-setting, task performance, and propensity towards laboratory hazards (Kolil, V.et.al., 2023).

Figure 1. Meta-analysis of theoretical study in STEM education (Ersozlu & Barkatsas, 2024).

couple of decades in higher education institutions in Mexico (Quintero et al., 2022: p. 219). This finding suggests that the lack of presence of female scholars in STEM will negatively affect the inspiration to pursue, achieve, and dispel knowledge to younger women, resulting in significant disparity among future generations of educators.

4. Economics of STEM Preparedness

As with all things, there is a financial aspect to STEM education. Candidates for careers in science, technology, engineering, and math must often endure long periods of foundational knowledge in undergraduate and graduate studies, which leads to expensive and burdening debt. STEM candidates' ability to avert and resolve this dilemma often relies on attaining good jobs with high, competitive salaries. More affluent countries, like the U.S., compensate their STEM workforce with average salaries of \$88,000 - \$96,000, and challenging student debt is handily resolved through two critical streams of employment strategy:

“The professional STEM economy of today is closely linked to graduate school education but functions mostly in the corporate sector and keeps American businesses on the cutting edge of technological development and deployment. The second STEM economy draws from high schools,

workshops, vocational schools, and community colleges; these workers today are not directly involved in invention but are crucial to the implementation of new ideas and advise researchers on the feasibility of design options, cost estimates, and other practical aspects of technological development” (Toner, 2011).

4.1. Demographics

The Recent reports from the National Science Board indicate that the STEM workforce consists of about 24% of the total U.S. workforce; the initial ascent occurred between 2011 and 2021. Unfortunately, there was a notable descent from 2019 to 2021 (National Science Board, 2024). Another notable trend reflects the current status of foreign-born workers in STEM occupations, as noted in **Figure 2** Prevalence of workers in STEM occupations by foreign-born and citizenship status: 2021.

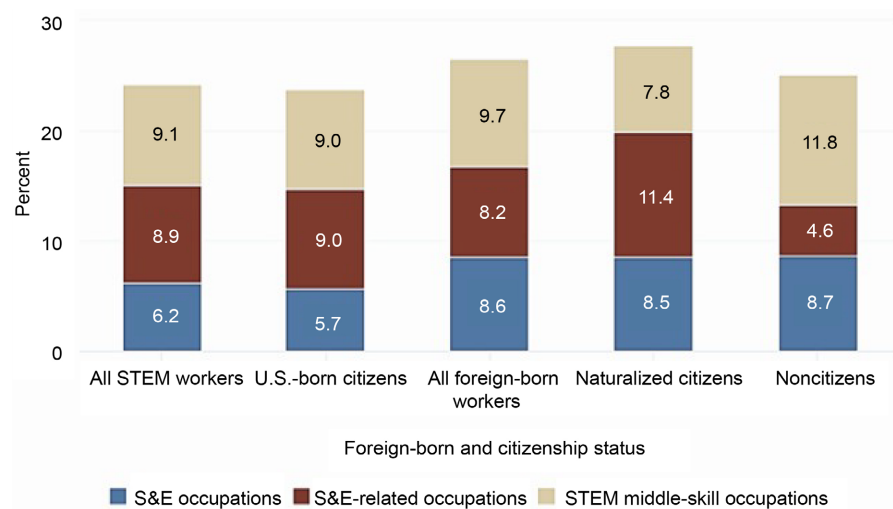


Figure 2. Demographics of STEM workforce domestic and foreign-born students (National Science Board, 2024).

This time study reflects the demographics of STEM workers in the U.S. economy from 2019 to 2021. The total number of STEM workers in 2019 was 6.2 % of the available workforce. During that same year, 5.6% were U.S.-born citizens, 8.6% were foreign-born citizens, 8.5% were naturalized citizens, and 8.7% were non-citizens.

4.2. Labor Challenges

Foreign-born talent is considered crucial to the U.S. economy because these students and native scholars provide the basis for significant investment in research and development in both the corporate and university sectors. An eight-year trend study indicates that the total number of undergraduate foreign-born students began at 275,000 (2012), peaked at 415,000 (2016), and has since declined to 360,000 (2020). Enrollment statistics for foreign-born graduate level were similar; they

began at 110,000 (2012), rose to 160,000 (2016), and declined to 140,000 (2020). The most significant loss to marginalized countries of STEM talent occurs at the highest echelon of STEM (see **Figure 3** Foreign-born Students Who Earn STEM Degrees).

Year	Undergraduate	Graduate
	Foreign-born Students	Foreign-born Students
2012	275,000	110,000
2013	305,000	125,000
2014	355,000	145,000
2015	375,000	155,000
2016	415,000	160,000
2017	405,000	160,000
2018	410,000	175,000
2019	405,000	175,000
2020	360,000	140,000

Figure 3. Foreign-born Students who earn STEM degrees (NSB, 2022).

“Approximately three-quarters of noncitizen science and engineering doctorate recipients stay in the U.S. following graduation, and many of them become U.S. citizens, this population of the workforce is substantial and has continued to increase in recent decades” (National Science Board, 2022). This could be attributed to one or more of the following conditions: a worker’s economic or financial condition, desired quality of life, or accessibility to the required knowledge and technical community required to maintain scholarly credentials and work experience. No one can control the eventual destination of these students; however, marginalized countries can create alternate paths toward educational endeavors that lessen the impact of this loss.

Although creating an antidote to the disease was the primal objective, many other STEM-related tasks complemented this effort. This included the creation of testing kits, the protocol for the intake and administration of existing COVID-19 patients, the assembly and mechanism for distributing medical antidotes and associated medical supplies, etc. Workers in small and marginalized countries could assist in these efforts in the future if properly trained and certified. The following section introduces some case studies that were conducted in several geographic regions designed to help promote STEM advocacy and retain scholarship.

5. Retaining Intellectual Assets

5.1. Case Study 1—Brazil

During the pandemic, Brazil experienced a common theme like many other countries in its lack of preparedness for emergencies. The most common issues were categorized as needing more certified resources to teach others how to respond to STEM-related situations and needing more infrastructure to support technological needs during these events. Brazil lacked a strong presence in biology and

computer science courses because many of their instructors had not been exposed to these disciplines when they attended school. Lucia Dellagnol notes, “teacher training is a serious obstacle because a self-assessment (by 100,000 teachers) indicates they do not feel confident in using technology primarily because they did not receive such training when they studied for their teaching degree” (British Council, 2023: p. 34). As a result, Brazil has aggressively developed a phased approach to implementing STEM disciplines within its instructional community so they can become “confident and certified” in these efforts and produce solid curriculum for elementary, middle school and high-school students. Researcher (British Council, 2023: p. 35) posits, that “smaller countries, such as Estonia, some regions of China, and Singapore, have made smaller investments in financial terms but have succeeded in making significant improvements in their educational results, with technology being key to this” indicating that Brazil is also capable of such progress.

5.2. Case Study 2—Ghana

Ghana community leaders recognized the need for greater depth and immersion in STEM disciplines several decades earlier. They instituted STEM educational clinics during the 1980s, followed by concentrated educational programs designed for the advancement of women in STEM during the 1990s (Ansong et al., 2020). Assessing these programs reflected the need for further investigation to determine better strategies for success. The study of 135 participants reflected that the overall performance of urban students still exceeded that of those from rural areas. Although students in rural areas began with a significant momentum toward academic excellence, their scholastic persistence did not sustain them in the program as time progressed. However, they did conclude that the “interventions in the late 1990s helped narrow the urban-rural gap in access to STEM laboratories and equipment for effective teaching and learning of science, but this program only targeted the senior high level” (Ansong et al., 2020: p. 15).

5.3. Case Study 3—Singapore

The following report was submitted on behalf of the Ministry of Education in Singapore regarding its approach to establishing educational assets in support of STEM:

“In 2005, the National University of Singapore High School of Mathematics and Science (NUS High) was established to offer advanced mathematics and science programs for academically talented students in these disciplines. NUS High is, thus, similar to the elite or selective STEM-focused schools or specialized STEM schools in the United States; a second STEM-focused school, the School of Science and Technology (SST), was established in 2010, this SST works closely with the local polytechnics to offer applied subjects such as Biotechnology, Computing, Design Studies, and Electronics to students; other informal STEM programs include the Shell Singapore: The

Bright Ideas Challenge held in 2017 and 2018 for secondary school students (Grades 7-10, aged 13-16) to pitch creative ideas for future cities that are vibrant, healthy, and clean to live in... in essence, the STEM education landscape in Singapore is enriched by supportive efforts from the Ministry of Education and ground-up efforts from private and public organizations” (Teo, 2019: pp. 2-3).

5.4. Case Study 4—United States

Researchers in North Carolina conducted a study of learning communities (LC) for STEM students to determine their efficacy. The study titled AToMS (Achieving Together in Math and Science) and IMS (Innovations in Math and Science) occurred from 2012 through 2014 and was funded by the public university system. Researchers (Carrino & Gerace, 2016) posit that 119 students self-selected into the LCs at orientation, and the initial population represented students from Chemistry and Biochemistry, Mathematics, Physics, and Computer Science. The research aims to analyze “how academic self-regulation, STEM identity, metacognition, and self-efficacy influence the psychosocial learning factors that students when interacting with faculty, staff, and other STEM professionals related to their academic development” (Carrino & Gerace, 2016: p. 1). Their initial findings revealed a strong correlation between the factors of academic self-regulation, professional and science identity, metacognition, and self-efficacy. This was strengthened by the second finding that co-location encouraged significant direct interaction, which fostered greater social forces that affect, shape, and mediate learning. This research undergirds similar efforts (in many colleges and universities), which offer early co-location learning communities for their incoming freshman class each summer before the formal term or semester begins.

6. Opportunities for Innovation

Education is crucial to the advancement of a society. However, not all communities can enjoy access to knowledge sectors as easily as others. We are embarking on new streams of knowledge that expand these capabilities. Artificial intelligence tools can offer new options for geographic regions that have limited teaching and technology resources. The following section introduces new strides in educational endeavors to advance the needs of other marginalized groups, such as individuals with developmental disability who lack accessibility due to economic conditions or physical barriers.

6.1. Artificial Intelligence

The challenges of the aforementioned mental models can be overcome with new tools. Researchers (Suomala & Kauttonen, 2022) posit perspectives on how artificial intelligence can augment human mental models and learning environments to build knowledge using physical, social, and cultural situations. In environments where instructional assistance is limited, studies are being conducted to explore

the rudimentary beginnings of such interventions titled artificial general intelligence (AGI). These include:

“learning intuitive mental models via reinforcement and self-supervised learning, assisting the human brain in keeping track of ongoing events, contexts, and evaluating decision-making options; this also includes solving engineering problems (e.g., building better predictive models), identifying predictive variables (e.g., apply regularization (rule-based normalcy) and finding correlations (relationships between factors or variables), benchmarking and other simple linear or non-linear models” (Suomala & Kauttonen, 2022: p. 13).

Another application option for mental models and AI includes using technology as an agent of complementarity in learning. In this scenario, the device acts as a coach or training partner, which can be particularly beneficial in memorizing vocabulary terms, short answer or rules-based knowledge, or linguistic skills (Kelly et al., 2023).

6.2. Neurodiversity

Scientific discovery reveals that some individuals with developmental disabilities possess exceptional skills in neurodiversity. Their highly sensitive sensory skills may enable advanced capabilities beyond their non-impaired faculty or students. The research efforts of (Chrysochoou et al., 2022: p. 9) suggest that “emerging technologies, in particular artificial intelligence (AI) and natural language processing (NLP), can be used to create a more customized and individualized learning environment that will support the unique ways of thinking and learning of neurodiverse students.” This means that AI could create new data streams of textual or educational formats, assess learners’ progress, and offer customized curricula.

These examples of innovation offer disabled teachers (individuals that are not severely impaired) several options for engaging in educational settings. First, they could participate in standard learning models and provide instruction in primary and secondary schools. Next, they could provide educational support in test preparation classes or centers to help students learn and memorize terms, concepts, and principles for standardized assessment. Another educational opportunity is using virtual reality (VR) and augmented reality (AR) tools. Roblox is a “sustainable and shared 3D virtual space in the creative virtual universe” that enhances student learning by “deepening their immersion and interests using science fiction platforms” (Zhai, 2024: pp. 464-465). Finally, they could participate in areas of educational assessment, providing support as test proctors in-person or via web conferences (Fleming, 2021) because many have skills in neurodiversity, which enables them to have higher degrees of sensory perception.

7. Findings

This article sought to explain the phenomenon of unpreparedness within

marginalized communities for life-altering events such as the recent pandemic (COVID-19). The author posits that the issues stem from the absence of educational resources necessary to develop foundational knowledge in science, technology, engineering, and mathematics (STEM) to adequately prepare these countries to interact and participate with other countries within the World Health Organization to develop strategy and implementation strategies to concur the disease. The research began with a definition of marginalization, followed by a discussion of how societal stereotypes and mental models can blemish the perceived value of smaller countries in their efforts to offer some assistance in these matters. This was followed by a literary review of the current literature in STEM education, revealing several critical themes toward academic preparation for prospective scholars. Next, a discussion of the economics behind STEM education was presented. This highlighted some key demographics and challenges facing foreign-born students (of marginalized countries) seeking higher education in other regions. The following section introduced four case studies of STEM educational initiatives in four distinct countries (North America, South America, Eurasia, and South Africa). The author then presents some novel concepts in innovation that could provide alternatives to the large migration of STEM candidates seeking higher education in larger countries or the ability to retain intellectual assets through knowledge transfer through the creation of international learning centers, as noted in the earlier case study. It concludes with some additional options to educate and expand marginalized STEM communities through the integration of a hidden community of educational support instructors with light impairment levels (disabled teachers) that are capable of supplementing needs in these areas when coupled with tools and technology that support distance learning, artificial intelligence, and neurodiversity.

8. Conclusion

Small countries that do not possess structured programs toward excellence in science, technology, and engineering programs are the most vulnerable populations because their persistent marginalization towards medicine and technological advancement creates a perpetual dependency on others for their survival. Many of their high-school graduates leave the country in search of higher education so they can expand their knowledge and become more sustainable. As noted in **Figure 4**, the top choices for these foreign exchange students include countries like Australia, Canada, and the UK (Studee, 2020).

Unfortunately, there are trends when students reach doctoral levels of study because they tend to establish residency in the destination country, leaving the marginalized communities at perpetual risk of inadequate teaching resources. Several options exist that might reduce this dilemma, one of which includes the creation of learning communities, as discussed in the examination of case studies proposed by several countries to enhance and expand STEM education. This involves using foreign exchange students that have completed their doctoral studies



Figure 4. Distribution of STEM foreign exchange students by country. Foreign-born students enter many different countries in search of STEM high education. This graphic demonstrates the top ten destinations for STEM study and the originating countries (home of foreign-born student from which they departed or out-flow).

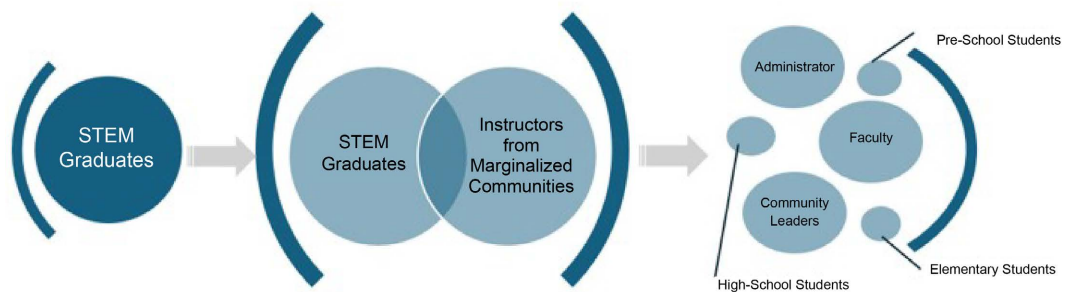


Figure 5. Vision for STEM international learning communities in marginalized countries.

to return to their native communities in-person and virtually to conduct training sessions to help prepare the educational community (faculty, administrators, and community leaders) on best practices, development of curriculum, and the integration of novel concepts like artificial intelligence and neurodiversity to help augment learning endeavors (see **Figure 5**).

A potential strategy for the international learning community (ILC) could be starting the segment with three (3) required in-person speaking engagements coupled with workshops for faculty, administrators, and community leaders. This would be followed by three (3) additional required web conferences (with the same groups) to report status, resolve obstacles, and refine pedagogy.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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