

STEM EDUCATION: Teaching with the Brain in Mind When Diversities and Gender Interlocks

Maxine McKay
University of Belize, Belize

ABSTRACT

STEM education is becoming increasingly recognized as a key driver of opportunity, and data show the need for *STEM* knowledge and skills will grow and continue into the future. Graduates who have practical and relevant *STEM* precepts embedded into their educational experiences will be in high demand in all job sectors. It is estimated that in the next five years, major American companies will need to add nearly 1.6 million *STEM*-skilled employees (Business Roundtable & Change the Equation, 2014). Labor market data also show that the set of core cognitive knowledge, skills, and abilities that are associated with a *STEM* education are now in demand not only in traditional *STEM* occupations, but in nearly all job sectors and types of positions (Carnevale, Smith, & Melton, 2011; Rothwell, 2013)". To add, with the constant changes in how students learn and the diversities that are present in classrooms today it extremely indispensable for various approaches to be used to reach all learners and those who teach and interact with these learners, must also be fully equipped. This study explored ways in which *STEM* (*Science, Technology, Engineering and Math*) can be used to make education and learning more comprehensive, real, practical and applicable to all types of learners. The author also brings to the forefront approaches and strategies that can be used to afford diverse learners, and males and females the opportunities to learn in all educational disciplines without prejudices. The study also sought to determine which *STEM* practices best caters for both male and female learners and the impact it has on their learning and critical thinking. The study utilized historical literature, personal communication and observations. Key recommendations include the following: there should be less traditional teaching, an increase in exploratory learning and more hands on approaches.

Keywords: ***CRITICAL THINKING, LEARNING STRATEGIES, TEACHING STRATEGIES, GENDER GAPS, GENDER EQUALITY, INNOVATION, CURRENT PRACTICES, METHODS OF LEARNING***

INTRODUCTION OF THE STUDY

"Education either functions as an instrument which is used to facilitate integration of the younger generation into the logic of the present system and bring about conformity or it becomes the practice of freedom, the means how men and women deal critically and creatively with reality and discover how to participate in the transformation of their world (Freire, 1968) ." This research explores teaching, the Brain and *STEM* Education. To add the Brain is a multifaceted and extremely powerful structure; hence, relevant and innovative education strengthens its function. Furthermore, unless humans particularly, students are challenged to think – beyond textbooks they will not be able to reach their maximum potential. Therefore, it is infinitely important for educators to provide all learners regardless of abilities and gender with opportunities to learn. Educators should be innovative and open to all types of teaching and learning, so that they can provide educational and euphoric learning opportunities for the individuals who enter the "diverse classrooms" around the world.

THE RESEARCH PROBLEM

Many people have a superficial concept of education equating it with doing a particular course or obtaining a particular qualification"¹. The noted perhaps is the common thinking of many; thus, for the value of education to reach a modern - innovative - non-discriminatory platform all aspects must be explored, and in this case "*STEM*" – the buzz in education today. *STEM* is:

“*Science, Technology, Engineering, and Mathematics*, and encompasses a vast array of subjects that fall into each of those areas listed. While it is almost impossible to list every discipline, some common *STEM* areas include: aerospace engineering, astrophysics, astronomy, biochemistry, biomechanics, chemical engineering, chemistry, civil engineering, computer science, mathematical biology, nanotechnology, neurobiology, nuclear physics, physics, and robotics, among many, many others. It is clear that *STEM* fields affect virtually every component of our everyday lives”.

Thus given the high incidence of drop-out rates and academic achievement gaps that exist between males and females globally, regionally and locally (Belize) it is important to see what measures can be taken to help narrow the gaps using approaches such as *STEM*.

PURPOSE OF THE STUDY

The purpose of this qualitative study was to (1.) explore ways in which *STEM* (Science, Technology, Engineering, and Math) can be used to make education and learning more comprehensive, real, practical and applicable to all types of learners, (2.) explore approaches and strategies that can be used to afford diverse learners, males and females opportunities to learn in all educational disciplines without prejudices and (3.) to determine which *STEM* practices best cater for both male and female learners and the impact each has on their learning and critical thinking.

SIGNIFICANCE OF THE STUDY

The results of this study are important for educators and policy makers, as it sheds light on some strategies and practices that work for both male and female learners. It also makes suggestions regarding strategies that can be used to better equip and teach learners while using *STEM*.

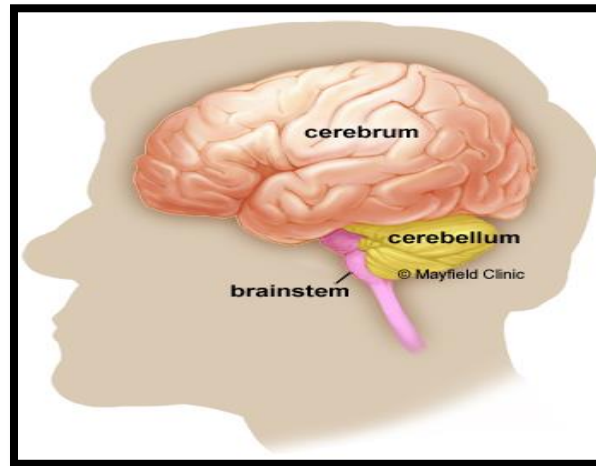
LITERATURE REVIEW

The Human Brain

There are key things that are important when it comes to learning and one such element is the ability of the brain to receive and process information. The Brain is perhaps the most essential organ that is stored in the human body, and without it humans simply cannot function. The Brain can do many things, thus adding to its complex makeup and power. Needless to say the Brain is best defined as:

‘The command center for the human nervous system. It receives signals from the body's sensory organs and outputs information to the muscles. The Brain has the same basic structure as other mammal brains , but is larger in relation to body size than any other brains². The Brain provides humans with the ability to use all other senses and helps the body to function, so without a proper functioning Brain it would be difficult for humans to do anything. The Brain and the way it operates help to dictate how males and females process information, so it is important for educators to understand the key functions of the Brain as research shows males tend to process information base on interest unlike their females counter parts.

Image 1: Human Brain



STEM Education

STEM education is quickly gaining popularity around the world and one of the aim of STEM is for all learners to benefit from its use in the classroom setting. Thus in order to understand the value and purpose of STEM it is important to understand its frame. In STEM education:

“Students are extremely curious and impressionable, so instilling an interest at an early age could spark a lasting desire to pursue a career in any of these fields. By the time a student is ready to enter the workforce, they must have enough knowledge to make invaluable contributions to our nation’s STEM industries. It is also important that schools have an ample amount of teachers who are experts in STEM, and these subjects should always be considered as high demand subjects. Teachers who follow an alternative route to teacher certification are at an advantage to teach in a STEM field if they majored in one, or are transitioning from a STEM-related career. If you are interested in becoming a teacher and you have studied chemistry, biology, physics, calculus, engineering, or any other STEM subject, you will be a great asset to your school. (Administrators, you count too: many advanced degrees for education leadership focus on subjects in STEM, particularly education technology. Since administrators set the tone for schools and entire districts, it’s important that you care about advancing STEM awareness and proficiency too).”³

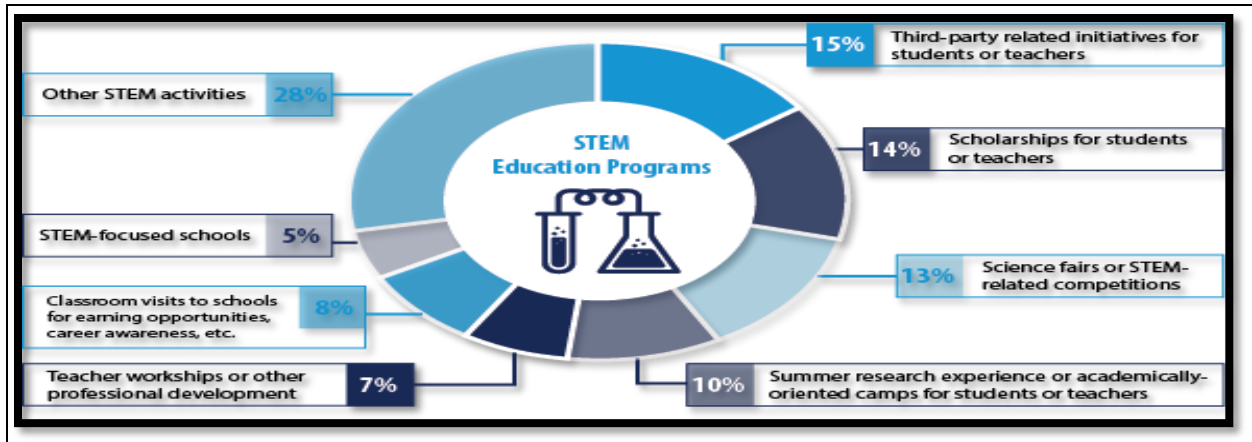
The above shows that schools need to be better ready to address the readiness of all types of learners if STEM is to be effectively used. The latter is inclusive of all stakeholders in education.

STEM Education is also defined as:

“An interdisciplinary approach to learning, where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise—enabling the development of STEM literacy, and with it the ability to compete in the new economy (Tsupro, Kohler, & Hallinen, 2009).

Additionally, (Dixon & Hulton, pg. 2, 2016) also noted that “STEM education is widely believed to be essential in preparing a more modern workforce with the competencies to address the technological challenges of the 21st century, increase the competitiveness of companies that increasingly have to function in a global economy, and also increase the number of engineers and scientists”. The noted again suggest that STEM education provides individuals with the opportunities that far exceed what other courses provide.

Illustration 2: STEM Education Programs



Gender and STEM

Often times research suggest that males lag behind their female counter parts in specific countries like those in the Caribbean and Latin America, but globally females lag behind their male counter –parts; thus, what *STEM* seeks to do is close or rather narrow the gender gap that exist when it comes to education as it relates to the areas that make up *STEM*. Furthermore it is essentially important to better explore the term gender for the purpose of this paper.

Risman and Davis (2013) suggest that:

“The term gender refers to the cultural meaning constructed around what it means to be male or female. It does not correspond in a straightforward way to biological sex; in fact, there may be greater gender differences between two girls than between a girl and a boy. Gender is thus not just a personality characteristic, but is something that is constructed and continuously negotiated across an individual’s personality, interactions with others, communities and culture”.

It is also important to cite and provide evidence of best strategies that cater for both genders, because research shows that females may lag behind their male counter parts, in several areas that *STEM* cover. Additionally there is also a clear gender gap in *STEM*; thus, the importance of understanding the practices that can be used that cater for both genders and thus help each reach their fullest potential. The latter noted is supported by a researcher that suggest that:

“The gender gap in *STEM* around the world has led to increased media, policy, and institutional attention. Much of the focus has been on the percentages of women in *STEM* fields and the lack of women in leadership roles. Yet, the underrepresentation of women who are trained in *STEM* fields or are recruited into *STEM* jobs is only part of the equation. There is a critical need for deeper exploration about the embedded cultures of learning and research that are impeding innovation and inclusion in these fields. A process of gendering *STEM* education could uncover the underlying assumptions that are limiting the participation of women and other underrepresented groups, while also expanding the intellectual space for new *STEM* discoveries and applications⁴⁷”.

It is also essential to note that there is ongoing research that speaks to the gap the is present when it comes to the fact that in the Caribbean and Latin American regions males continue to lag behind their female counter parts, in areas such as Language, Reading, Literature, the Arts and Social Studies, so the integration of *STEM* education may eventually close the large gaps that exist. Furthermore, one study reviewed also noted that:

“Stereotypes are pervasive throughout society and can influence beliefs about an individual’s strengths and shortcomings, even when evidence of their skill level indicates otherwise. These beliefs can influence the way in which individuals think, behave, and feel about their own abilities, in addition to the way in which they view others. Therefore, we need to combat negative stereotypes by highlighting the achievements of women and girls in *STEM* areas. For example, the school and home environments are important sources for sparking Science interest in girls, teachers and parents can communicate that men and women are receiving equivalent achievement in nearly every *STEM* subject and that greater numbers of women have been entering and succeeding in *STEM* fields in recent years. Eliminating stereotypically “masculine” objects from *STEM* classrooms may also increase women’s interest in those fields by removing perceptions that these fields are not for women (Cheryan et al. 2011a; Cheryan et al. 2009). Finally, the media should strive to create more positive portrayals of female professionals in *STEM* fields, so that girls and women encounter well-rounded and realistic images of successful women scientists”.

To add the debate around which gender is better in the *STEM* subjects continue to be a debate that many do not want to address, but the literature is evident. In several observations done in pre-selected classrooms in Belize, it was found that a disparity still exist between which gender is performing better in the various subject areas. One literature reviewed noted that:

“A richer understanding is needed of the unique interplay between Science, Math, English interest, and achievement in determining women’s career choices. Studies done explored how relative math versus verbal ability predicts career choice (Chow et al. 2012; Wang et al. 2013). Having a science/math/technology trait profile was associated with greater knowledge in the physical sciences and technology, while having a verbal/intellectual profile was associated with greater knowledge in the humanities, civics, and the biological and psychological sciences. However, little is currently known about the relative impact of science, math, and English interest and ability on men and women’s *STEM* educational and career choices. For example, the practice of combining Math and Science into a general Math-Science factor or examining them in separate models (Simpkins et al. 2006) limits the field’s ability to compare their influence. Without this specificity, it is difficult to know if high math and science interest are equally important for choosing *STEM* or if high interest in one domain can offset the effects of low interest in another. Furthermore, since women are more likely to pursue science fields that are less math-intensive, it would be valuable to know whether higher math ability and interest relative to science are more important for math-intensive careers and whether higher science interest and ability relative to math are a factor for less math-intensive *STEM* careers. Ultimately, additional research is needed to answer questions regarding the relationship between domain-specific ability and motivational factors”.

Furthermore, with the diversity that is present in classrooms around the globe and in particular the Caribbean Latin America, it must be understood how the use of *STEM* can help students who have varying disabilities. Basham & Marino, 2010 (as cited in Hwang and Taylor (n.d)) notes that the “importance of *STEM* from a global perspective, teaching and learning *STEM* disciplines are also valuable in enhancing the quality of daily for students, especially for those with disabilities (pg. 40)”. The latter indicates another value of *STEM* to learners. Several research suggest and informs that *STEM* , helps to increase students’ advanced knowledge , an element that is linked to critical thinking one of the most essential and ultimate goal that we would want all learners to achieve regardless of their gender or ability. The latter noted is especially important particularly, since it has been cited that:

“The quality of math and science teachers in the Caribbean is also of concern. According to the Caribbean Centre for Competiveness (2014), the World Bank indicated that the availability of adequately trained teachers in mathematics and key science subjects remains a concern in the region. This presents a major challenge as it is becoming increasingly evident that *STEM* education is necessary to support a 21st century workforce”.

METHODOLOGY

Design of the Study

The author utilized archival data to generate supporting evidence for the study as well as personal

interviews with a randomly selected sample of 5 persons (N= 5) who work in the educational system in Belize. The sample that was interviewed consisted of 3 females and 2 males. Each person was asked 5 questions that were set out by the researcher. The responses were reviewed and organized base on similarity of the responses. This is presented in the data analysis section.

Data Analysis

The archival data that was retrieved was organized base on the application of the areas that were studied as it relates to relevance and appropriateness. The findings that were gathered from the archival data as cited in the literature also guided the questions for the personal communication sessions that were held. The responses from each participant were manual recorded, typed and verified with the participants before it was used in the study.

FINDINGS

This section presents summary of the findings from the archival data as well summaries from the responders.

Archival Data Summary Report

The research suggest that there is a gap that persist as it relates to male and female when it comes to *STEM* education . The following narrative presents measures that can be taken to address the objectives of the paper:

BELOW IS A LIST OF THE BEST PRACTICES FOR STEM CURRICULUM PROGRAMS AS CITED BY VARIOUS AUTHORS FROM DIFFERENT COUNTRIES

- ☑ **Integrated Content⁵**
Science, technology, engineering and math are approached from a real-world, integrated perspective.
- ☑ **STEAM and Beyond**
A true transdisciplinary framework integrates fine arts, social studies and language arts to appeal to a broad range of learner interests.
- ☑ **STEM for ALL Students**
Effective STEM programs engage and inspire students of all abilities and interests and accommodate a wide variety of learning styles.
- ☑ **Next Generation/21st Century Skills**
Promotes problem-solving and critical thinking, creativity, collaboration, communication, time management and adaptability.
- ☑ **Personalized Learning**
Personalized learning is individualized, differentiated, and relevant to the interests and experiences of each and every student.
- ☑ **Project-Based/Problem-Based Learning**
STEM content is learned through hands-on, minds-on projects. Project engagements are motivated by genuine learner inquiry and a problem-based perspective.
- ☑ **Authentic Assessment**
Learners document and present their learning through ePortfolios or similar methods.
- ☑ **Integrated Learning System**
All program elements, including classroom configuration, hardware, software, kits and equipment, curriculum and assessment, and professional development support learning objectives.

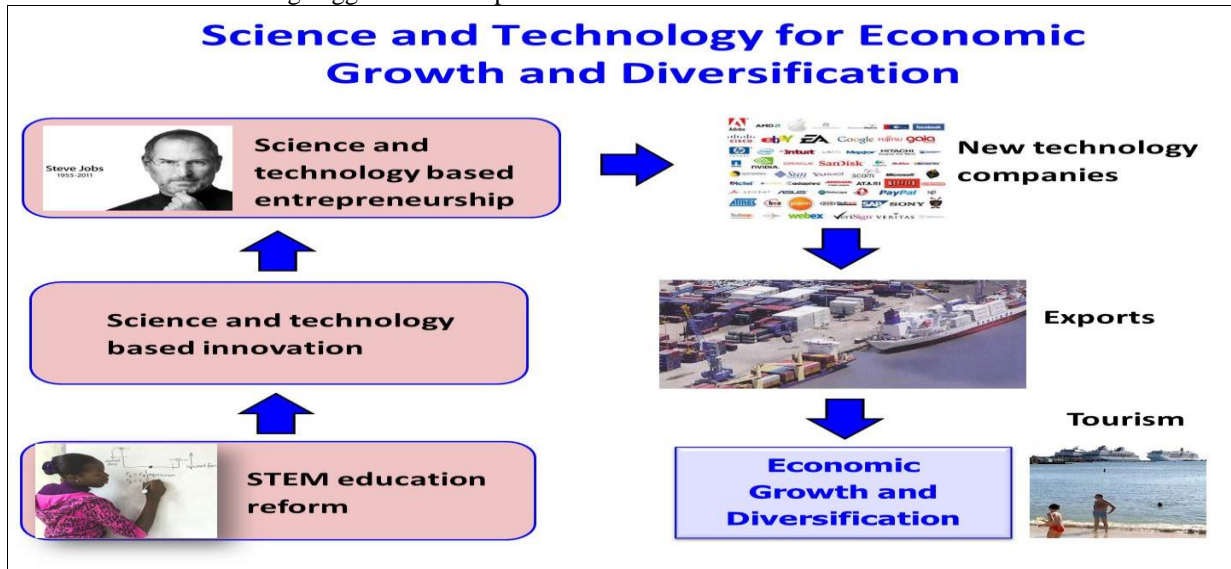
- ✓ **Technology-Enabled Learning**
Professional-standard technology tools are integrated into everyday workflow.
- ✓ **Learning Technology vs. Teaching Technology**
Technology is in the hands of the students, not just teachers, administrators and service providers.
- ✓ **Emphasis on Applied Technology**
Application of technology tools is emphasized over specific skills that become obsolete as technology changes.
- ✓ **Teacher as Facilitator**
Teachers assume the role of facilitator and students are empowered to take responsibility for their own learning.
- ✓ **Collaboration**
Students work in pairs or larger teams. Quality collaboration is as important as the final work product and is part of the regular assessment process.
- ✓ **Articulated Learning**
Program elements scaffold from K-12 with increasing levels of challenge and self-direction.
- ✓ **Open-Ended Learning**
Students select an appropriate level of challenge and take their projects as far as they're able.
- ✓ **Supported and Sustainable**
Ongoing professional development is an integral program element. Program continuity is not dependent upon a single teacher. Program technology is readily available. Technology and curriculum resources are regularly updated and augmented.

Another source reviewed suggests the following as best practices for STEM education Faust (n.d) as cited by Wong (n.d):

1. Provide teachers professional development on how to use the technology, but also on how to incorporate STEM activities into their courses.
2. There is no one-size-fits-all with technology.
3. Foster interest by allowing students to create STEM clubs.
4. To teach STEM successfully, students and teachers alike must embrace culture change.
5. Consult experts when designing STEM courses and labs.

- Coordinated collaboration between stakeholders across the STEM ecosystem. Stakeholders commit to actionable strategies that change the culture of STEM to be equitable for all, where there is a balanced representation of all groups of people within the STEM ecosystem;
- A shared vision, priorities and common language around STEM to develop a collaborative, positive and inclusive STEM culture within and outside of education and industry contexts;
- Sustainable inclusive education and engagement for all STEM fields, from early childhood through to professional leadership;
- Curriculum implementation (both in school classrooms and outreach) that empowers students through choice, skill development and allows students to realize real world applications of STEM; and,
- Sustained professional development, capacity and engagement of teachers.

Warde and Sah (2014) provided in the report entitled the *STEM Education Reform Considerations for the Caribbean* the following suggestions to improve *STEM* education in the Caribbean.



Results from Personal Interview (Personal Communication)

The table below shows the collated responses from the 5 educators who responded to the questions asked in the interview.

<p>What are ways in which STEM (Science, Technology, Engineering, and Math) can be used to make education and learning more comprehensive, real, practical and applicable to all types of learners</p>	<p>Approaches and strategies that can be used to afford diverse learners, and males and females the opportunities to learn in all educational disciplines without prejudices</p>	<p>Which STEM practices best caters for both male and female learners and what impact does it have on their learning and critical thinking</p>
<p>Some of the ways that educators can make STEM education more comprehensive , real and practical are as listed:</p> <ol style="list-style-type: none"> 1. Taking students on more field trips 2. Bring in more guest speakers 3. Do less chalk and talk and more hands on- let students see, feel and explore their own learning 4. Place learners by their abilities and interest from early 5. Teachers need to be more trained 6. Place Based Learning 	<p>There are several strategies that can be used. These include:</p> <ol style="list-style-type: none"> 1. Placed Based learning approach where the learner is given the opportunity to learn 2. Cooperative Learning 3. Peer- Learning 4. Field Learning 5. More Hands On Approach 6. Workshops 7. Works Force Exposure 8. More Technology 	<p>There are several practices that cater for both males and females :</p> <p>The respondents believe that a combination of their responses from question one and two are the best strategies.</p>

CONCLUSION

Conversely there are many who suggest that *STEM* education does not work for all learners, because students come with different multiple intelligences, and although this may be true *STEM* focuses on all possible disciplines; thus, the use of it to teach both males and females should help them to be more critical thinkers. In several personal communication done in other to collect the sufficient data for this text, it was clear in the Belizean and localized context that *STEM* education is not a common household term, in the once colonized territory and it is for the most part the same in other territories. However, there are some countries in the Caribbean such as Barbados that have made attempts to utilize *STEM* to help in improving students' performance in regional, local and national exams; however, there continues to be pitfalls. It is suggested that in:

“The Caribbean is known for its tourist destination and strong hospitality industry. Warde and Sah (2014), however, indicated that the protracted weak rates of growth and high borrowing levels over many years have left the Caribbean the most heavily indebted region of the world. This indebtedness limits fiscal flexibility, discourages private investment, and pushes up borrowing costs, creating a vicious circle. For example, in Jamaica, the inability to solve the dire economic problems constitutes the basic reason for proposing a *STEM* programme for the education system. The gradual reductions in manufacturing, and over-reliance on a mediocre service and banking sector, have not helped the economy of Jamaica. This reinforces that for there to be significant economic growth; Jamaica must urgently develop and tap into strong *STEM*-trained human capital. Over the years, however, universities have consistently turned out more graduates in non-*STEM* fields than in *STEM* fields, pointing to a lack of *STEM* identity among most students who are entering higher education.

RECOMMENDATIONS

1. **TEACHERS NEED TO BE TRAINED IN STEM EDUCATION**
2. **POLICIES NEED TO BE CREATED AS NONE ARE REALLY PRESENT IN THE CARIBBEAN COUNTRIES**
3. **MORE FOCUS SHOULD BE PLACED ON OTHER AREAS IN STEM AND NOT JUST MATH AS IS THE CURRENT PRACTICE IN THE CARIBBEAN**
4. **EDUCATORS NEED TO TAKE LEARNING OUTSIDE OF THE TEXT**
5. **EDUCATORS SHOULD PROVIDE BETTER LEARNING OPPORTUNITIES FOR STUDENTS**
6. **IN ORDER FOR STEM TO BE MORE PRESENT IT SHOULD BE MADE PART OF THE NATIONAL CURRICULUM IN THE CARIBBEAN AND LATIN AMERICA**
7. **THERE NEEDS TO BE AN INCREASE IN MORE LEARNER BASED ACTIVITIES**
8. **MORE USE OF TECHNOLOGY**
9. **MORE HANDS ON – LESS CHALK AND TALK**
10. **MORE REAL LIFE APPLICATIONS**

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iii <https://teach.com/become/what-can-i-teach/stem/>

² <https://www.livescience.com/29365-human-brain.html>

⁵ <https://www.creativelearningsystems.com/stem-education.aspx>