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National STEAM Education Report Jamaica: Towards Developing a Strong STEAM Ecosystem

Message from the Honourable Fayval Williams Ministry of Education and Youth

In recent years, Governments of advanced nations across the world have placed a particular emphasis on improving the quality of education in Science, Technology, Engineering, Arts and Mathematics (STEAM). This reflects the critical importance of STEAM disciplines for modern society. They empower our citizens in so many important ways. Science and Mathematics provide answers to the fundamental questions of nature and enable us to understand the world around us. Expertise in STEAM disciplines is necessary to drive our economic ambitions, support innovation and provide the foundations for future prosperity. Knowledge-based economies are particularly dependent on the quality and quantity of STEAM graduates. Providing STEAM education of the highest quality is essential if Jamaica is to deliver on its ambitions to be a hub of technological creativity and a leader in innovation.

Increased post-secondary STEM enrolment has been designated as a national imperative by the Ministry of Education and Youth (MoEY). This role recognizes the vital need for Jamaica to raise the degree of creativity and critical thinking necessary for future employment and economic success. This is our strategy for Research and Development, Science and Technology, and highlights the critical importance of excellence in STEAM Education to ensure the continuous development of a pipeline of talent to support both Local and Foreign Direct Investment and an active ecosystem for indigenous start-ups. To accomplish any or all of the purposes and objectives of STEAM education, clearly educated and trainable individuals who can adapt to the changing environment and its requirements are essential.

We must address the country's unequal access to technology and weak physical infrastructure. Above all, we must improve fundamental literacy abilities. Efforts to promote STEAM learning will be hindered if secondary pupils continue to struggle with reading comprehension. To address this, we have implemented the Specialist Subject Teacher approach at the elementary level, intending to improve the teaching and learning of English and Mathematics.

Furthermore, under the new National Standards Curriculum (NSC) for grades one through nine, which seeks to improve students' overall academic performance, attitude, and behaviour, an emphasis is being placed on project-based and problem-solving learning, with Science, Technology, Engineering, and Mathematics (STEM/STEAM) integrated at all levels.
We can proudly declare that the Ministry of Education, Youth, and Information is already implementing the wide embrace of STEAM education as one of its strategic goals, rather than merely as a distinct discipline to be taught.

We also recognize that to deliver a world-class STEAM education to our children, our teachers must have access to high-quality training and professional development programs and resources.

The Jamaican government believes that all young people should have free access to science, technology, engineering, and math education. We are aiming to achieve this by making it simple for STEAM educators and others to access subject-specific professional development programs.
The Ministry's goal is to increase the number of students who graduate from high school with certification in a practical skill-based topic, and we have been emphasizing project-based and problem-solving learning, with STEM/STEAM being incorporated at all levels.

The Ministry of Education and Youth is committed to ensuring that no student is left behind as we work to bridge our society's education gap and train our people to be flexible and adaptable to the modern world.

The Honourable Fayval Williams MP
Minister of Education and Youth

National Education Trust

Rapid advancements in technology and changes in society are our everyday reality. The world continues to transform into a data and technology-driven environment where employees are required to use information and communications technology, analytical skills and innovation in their everyday work life.

To become more competitive as a nation, Jamaica must design and build a strong innovative economy that is driven by a technology savvy and critical thinking workforce. Where does that leave us as a nation? This means that the country must invest in new research methodologies and transform the education system to ensure that students are prepared for these jobs while being empowered to adapt to the requirements of the jobs of the future.

How then can we bridge the divide between the global market and our Jamaican classrooms? The answer lies within the goldmine of the teaching and learning process that must elicit, encourage and enhance critical thinking and collaboration while embracing technology. As such, we must develop a science, technology, engineering, arts and math (STEAM) education eco-system that prepares and advances Jamaicans for the future.

STEAM Education has been proven to create lifelong learners, innovative thinkers and problem solvers who are socially and emotionally adaptable. This workforce will anchor a resilient, self-sustaining economy that facilitates growth and development for all our citizens. STEAM is the way of the future and must be interwoven into the DNA fabric of our education system. This approach will put Agility, Innovation and Resilience at the core of our education sector.

For this reason, we are grateful for the partnership with the British Council in completing the research and this report, which will assist us in designing the STEAM policy and implementation plans for our STEAM project. The National Education Trust stands ready to do our part to breathe life in our education system with STEAM, so that we may realise the goals embodied in Vision 2030 Jamaica National Development Plan for a world-class education and training and internationally competitive industry structures.

Latoya Harris Ghartey
Excecutive Director,
National Education Trust

British Council Jamaica

The British Council is the UK's international organisation for cultural relations and educational opportunities. We create friendly knowledge and understanding between the people of the UK and other countries. We do this by making a positive contribution to the UK and the countries we work with – changing lives by creating opportunities, building connections and engendering trust.

This national Steam education report is the first of its kind in Jamaica and represents key information that will form the basis for further development of the education ecosystem in Jamaica. It is clear that there is a need to inform the public about Science Technology, Engineering Arts and Maths (STEAM) education and its role in contributing to Jamaica's economic growth.. We want to help young people, teachers and organizations at community and national levels to understand the role they play in this process. In order for Jamaica to build this ecosystem, we must encourage the various actors to establish a collaborative approach to improve learning outcomes for our students and to drive the growth of the sector. Public private partnerships such as the one established between the British council and the National Education Trust to develop this report, will provide unique opportunities to achieve important milestones. I am very pleased to introduce this report which highlights some key areas of potential that will create a more inclusive and accessible education system for all learners. We hope that the various actors will be able to identify more specific areas for targeted and sustainable intervention which will support the growth of the education ecosystem.

As Jamaica continues to develop strategies that will drive its socio-economic growth, improving educational access at all levels must continue to be a key area of focus. Aligning STEAM learning objectives with needs of the local labour market will allow for a more responsive education system that also responds to global trends. The report has signalled the need for increased funding, training and capacity building, and collaboration across partners to build the STEAM education sector in Jamaica. We hope that the information provided in this report will act as a catalyst to create an even greater coordinated sustainable strategy that synchronizes the work and role of the government and private sector players.

The British Council will continue to promote friendly knowledge and understanding between people of the UK and Jamaica by creating opportunities for learning and knowledge transfer in key areas such as STEAM education, which is of great value to both countries and the wider world.

The British Council acknowledges the work of the MICO Foundation, STEMunity and Dr Andre Coy who worked to produce this important research. Thank you to the British Council UK team Yvette Hutchinson and Adrian Fenton for their time dedicated towards the completion of the report,

Damion Campbell
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British Council STEAM Education Report

EXECUTIVE SUMMARY

This British Council commissioned report is based on an assessment of the current status of STEAM Education in Jamaica. Both public and private sector stakeholder groups were assessed. A key element of the report examines the extent to which existing STEAM education curricula are aligned with international benchmarks. A policy concept paper is included to guide the way forward.

The British Council aims for the report to serve as a baseline from which to monitor, grow and shape the ecosystem for STEAM Education in Jamaica. The report consists of five sections, each covering an aspect of the STEAM ecosystem. Section I is an introductory section, which explores the concept of STEAM Education and its value to the nation. Section II explores the idea of a STEAM ecosystem for Jamaica, while Section III examines the challenges to developing such an ecosystem. An approach to overcoming the challenges, and related policy recommendations for doing so, are presented in Sections IV and V.

A survey of the STEAM Education landscape is conducted beginning at the Early childhood level and encompassing Education at the primary, secondary and tertiary levels. The analysis also includes STEAM Education in Industry, and at the community level. The study employs desk research, curriculum mapping, surveys and interviews. The curriculum mapping exercise is conducted for Kindergarten to Grade 9, which are the grades covered by the National Standards Curriculum (NSC). To ensure that the NSC is implemented uniformly in all schools, the Ministry of Education and Youth (MOEY) has developed a set of standards , based on international benchmarks, to guide STEAM Education as articulated in the NSC. However, the standards are STEM based and do not consider many of the skills honed through STEAM Education. While this mismatch prevents a complete analysis of STEAM standards, it is deemed important to use the metric developed by the MOEY, not least, as a way of understanding how the NSC was being evaluated internally. The standards require that STEM is applied and integrated into curricula, and that curricula facilitate interpretation and communication of STEM content. Additionally, the standards require that students be led to engage in inquiry, logical reasoning, collaboration and demonstrate creativity and innovation.

The results show that there is a high level of STEM content integrated in the Early Childhood curriculum with particular emphasis on science, math, experiments, and graphing. Real-life situations are used and

logical reasoning is introduced through a number of different activities. Creativity is encouraged through projects that reflect real-life and the arts are well represented with song, dance. However, there is a lack of problem solving, low levels of inquiry and a lack of innovation opportunities reflected in the curricula. At the Kindergarten to Grade 9 levels, there is broad integration between the Standards and the NSC curricula, but only 21% of the reviewed curricula are well aligned to the standards. Just over two-thirds are exploring and developing alignment, while 11% are not aligned.

For Grades 10-13, students are being prepared for external exams, which do not allow for the forms of assessment recommended by the STEAM Education methodology, thus their curricula are not governed by the NSC. Nevertheless, STEAM Education is encouraged and support is provided by the MOEY. For this group, a definition of STEAM Subjects was developed in the report. STEAM Subjects were defined as STEM subjects as well as those digital subjects that are interdisciplinary and include the use of information and communications technologies (ICT). An analysis of the number of students sitting STEAM Subjects between 2009 and 2020 is conducted. On average, only 43% of the subject entries from public schools, at grade 11, were in STEAM Subjects – 27% of the passes at that level, were in STEAM subjects. For grades 12 and 13, 36% of the public school entries to sit CAPE exams were registrations for STEAM subjects 30% of the passes at CAPE were in STEAM Subjects.

The tertiary level consists of Universities (4%), Specialised Institutes and University Colleges (17%), General Higher Education Colleges (38%) and General Providers and Brokers (41%).

This segment of the STEAM landscape is shown to be quite varied in the integration of STEAM Education. For instance, Teacher training institutions head the list of integrators followed by technical and Vocational institutions. It emerged that there is great scope for further integration of the STEAM Education methodology at the University level. One of the areas ripe for integration is the active inclusion of undergraduate students in real-world research, which would involve partnerships with Industry to fund basic research as well as partnerships on research and development address current challenges and develop novel solutions.

Two of Jamaica's Vision 2030 goals are directly impacted by STEAM Education – Goals 1 and 3 speak to world-class education and training, and internationally competitive industry structures, respectively. As a result, having a strong STEAM-related work force is essential. An analysis of the STEAM-related labour market, using data from the Statistical Institute of Jamaica, revealed that in October 2021, the STEAM-related labour force This percentage, however, includes both skilled and non-skilled individuals, so the proportion of the workforce with STEAM-related skill sets is not clear. In addition to employing individuals with STEAM-related skill sets, Athe private sector is involved in supporting STEAM-related initiatives. A wide range of these initiatives are identified.

Community-based STEAM Education programmes are identified as contributing to the ecosystem. These initiatives were carried out by various groups, registered in the formal economy, while a large number of STEAM Education activities, such as informal TVET training, takes place without oversight or formal recognition.

Gaps in the STEAM Education landscape are were identified. These gaps fall within one of three categories:; lack of training, lack of funding and lack of collaboration; recommendations for creating a STEAM ecosystem focused on these gaps. Creative proposals for filling the gaps are made and a model for creating a STEAM ecosystem with a National STEAM Centre as the central coordinating body is shared. In this model, stakeholders are seen as both producers and consumers of STEAM content, the skills derived from STEAM Education and the attendant benefits of having a robust STEAM ecosystem.

Recognising the imperative of ensuring deliberate linkages between STEAM education and Jamaica's future economic development the following policy objectives are recommended:

1. To establish a national nodal centre for the coordination of all activities related to developing a STEAM culture in Jamaica.
2. To advance a cohesive national Integrative STEAM Education curriculum throughout the pre-tertiary phase of education.
3. Work with external examination bodies to allow for the development of assessments commensurate with the STEAM Education methodology.
4. The adoption of international STEAM Education standards.
5. To propose a framework for integration of the STEAM Education methodology across curricula in the tertiary sector
6. To formalise linkages between participating stakeholder groups to maintain relevance and to promote continuous innovation.
7. To develop standards for schools to be certified as STEAM academies.
8. To develop a national education campaign promoting the value of STEAM Education to the development of the economy.
9. To provide funding and support for a popular science programme created for traditional and new media
10. To create a fund to support STEAM research at the tertiary level

I. INTRODUCTION

The Case for STEAM Education in Jamaica

Having recognised the established relationship between education and economic development, successive governments in Jamaica have invested in infrastructure, numerous policy directives, and educational reforms as means of promoting greater access to education. Among the main objectives for this investment in the system of education is the promotion of prosperity for all Jamaicans by ensuring they are prepared to take advantage of existing and emerging government and private-sector jobs. “Every child can learn; every child must learn” is the slogan used by the Ministry of Education and Youth (MOEY) to capture the expected outcomes of the Jamaican educationsystem.

The world is shifting inexorably toward a more technology-driven, knowledge-based approach to work. Employees are increasingly required to use information and communications technology and analytical skills in their daily activities. As Jamaica aligns itself to participate and thrive in this environment, there is the need to ensure that students are being prepared for these jobs, as well as being empowered to adapt to the requirements of the jobs of the future. The teaching and learning process must, elicit, encourage and enhance these skill sets among learners.

A recent report on Education in Jamaica, produced by the Jamaica Education Transformation Commission (JETC), points to STEAM (Science, Technology, Engineering, the Arts and Math) Education as an approach that not only provides the kind of preparation required for work, but also helps to foster social and emotional development among learners1. In order to understand the benefits of STEAM Education, one must first have a definition, starting with its precursor, STEM Education.

What is STEM?

STEM is an acronym formed from Science, Technology, Engineering and Math and is generally understood to refer to a focus on the individual disciplines that form the acronym. When the concept was first introduced in the 1990s, it was referred to as SMET and was eventually changed to STEM in 2001[2]. The reason for developing the concept was that there were too few students, teachers and practitioners in the individual STEM fields. By introducing the term and popularising the fields, people could be enticed to study and work in the fields and fill the gaps that existed at the time.

STEAM Education is an approach to learning that uses Science, Technology, Engineering, The Arts And Mathematics as access points for guiding student inquiry, dialogue, and critical thinking.

Susan Riley
CEO, Institute for Arts Integration and STEAM

[1] Jamaica Education Transformation Commission. (2021). "The Reform of Education in Jamaica, 2021". https://opm.gov.jm/wp-content/uploads/flipbook/jetc-reform-of-education-in-jamaica-2021/ [2] Catterall, L. G. (2017). A brief history of STEM and STEAM from an inadvertent insider. The STEAM Journal, 3(1), 1–13.

The original idea emphasised Education in STEM – teaching and learning aimed at producing practitioners that are skilled in the individual disciplines. A related concept is that of STEM Education, which uses techniques that intentionally integrate the concepts and practices of STEM into the entire teaching and learning experience, regardless of the subject being covered. STEM Education broadens the scope of STEM and aims to develop individuals who are trained in, and readily employ the 4 Cs of 21st Century education: Creativity, Collaboration, Critical Thinking, and Communication. For clarity, this report will use STEM to refer to the individual subject areas, and STEM Education, to refer to the integrative approach to teaching and learning across the curriculum.

From STEM Education to STEAM Education

STEM Education is geared toward preparing critical thinkers who are able to adapt to the interdisciplinary, collaborative, increasingly technology-driven, nature of the jobs of today and the future. STEM Education, however, does not emphasise some of the skills that are in high demand, even among STEM graduates – skills such as: design, problem solving through the creative process, innovation, argumentation and presentation. These skills, which are fundamental to the Arts, are complementary to those stressed in STEM Education.

It thus, seems a natural progression, to train students to take advantage of these additional skills.

> STEAM is about more than converging the fine arts and design thinking into STEM fields. The liberal arts are, the 'who & why,' the reasoning, to the 'what & how' of STEM.
>
> **Georgette Yakman**
> STEAM Education Researcher

Science Technology, Engineering, Arts and Mathematics (STEAM Education is an approach that takes advantage of the complementary skills of STEM and the Arts to ensure the rounded development of learners, jointly fostering critical thinking, creativity and self-awareness. STEAM Education is thus, geared towards the holistic growth of all learners, not just those involved in pursuing education and careers in the individual disciplines. By providing learners STEAM Education competencies (subject knowledge as well as the skills and attendant dispositions highlighted in Table 1) STEAM Education promises to foster engaged citizens, lifelong learners, innovative thinkers and persistent problem solvers who are socially and emotionally adaptable.

Table 1: Practical STEAM Education Skills and the Qualities they Embed in Learners

STEAM Education Skills	Embedded Qualities				
Mathematical and Algorithmic Thinking				Critical Thinking	Interdisciplinary
Obtaining and Evaluating Information					
Engaging in Argument from Evidence					
Analysis and Interpretation					
Defining Problems	Creative	Creative	Collaborative		
Planning and Investigating					
Designing Solutions					
Implementing Solutions					
Productive Failure					
Constructing Explanations			Self-aware		
Communicating Solutions					
Critiquing Processes and Solutions					
Argumentation					

The nature of work has changed and will dramatically change in the coming years. Jamaica needs to build capacity for a 21st century economy; one that is driven by digital technologies, data, and innovation. This requires a skilled workforce that can create and use technology. A workforce that has the competencies engendered by STEAM Education will serve as the backbone of a resilient, self-sustaining economy that facilitates growth and development of, and for, all its citizens.

The contents of this report serve as a baseline from which to monitor, grow and shape the ecosystems for STEAM Education in Jamaica. Section II explores the idea of a STEAM Ecosystem for Jamaica, while Section III examines the challenges to developing such and ecosystem. An approach to overcoming the challenges, and related policy recommendations are presented in Sections IV and V, respectively.

Limitations

There are limitations in this study. These limitations are all related to data collection and the generalisability of the results presented. The first limitation concerns the data collected from educators. Survey instruments were sent to 93 randomly and purposively selected primary and secondary schools, located across the seven regions of the Ministry of Education and encompassing all fourteen parishes. The survey sought to ascertain their attitudes, disposition, and readiness for STEAM education, as well as an assessment of their ICT needs. A total of 219 educators from 47 schools responded. This response rate fell below the level that would allow for generalisations to be made, meaningful trends can be ascertained.

The second limitation is similar to the first. An Industry Growth Needs Assessment survey was conducted. Seventy businesses from 10 industries were purposively selected for this survey. However, due to the slow and low response rates, a Delphi Technique targeting the 10 selected industries was employed. In an effort to overcome some of the limitations of the Delphi Technique, elite interviewees were purposively selected for in-depth insights of the challenges, opportunities, and resourcing requirements for job creation and for education.

An effort was made to determine labour market trends, by surveying employees in STEAM - related industries. Sixteen firms of varying sizes falling within the STEAM industry clusters, with a reported staff complement of 4,300 persons were sampled. However, none of the respondents self-identified as being in the Science cluster. As a result, the analysis was not reported.

Finally, the STEAM Labour Force data from the Statistical Institute of Jamaica does not disaggregate skilled and unskilled labourers, so the analysis presented may not provide an accurate picture of individuals with STEAM-related skills in the labour force.

II. The Jamaican STEAM Education Landscape

STEAM Education Early Childhood – Grade 11

In 2016, the Ministry of Education, Youth and Information introduced the National Standards Curriculum (NSC) which emphasises the STEM Education for all approach. STEM Education for all proposes that STEM competencies are relevant for teaching and learning of all subjects and are also relevant for current and future jobs. This strategy was in part developed to bridge the gap between education and real-world job performance. Increasingly employers are reporting that even though employees may come to the job with STEM subject content knowledge and qualifications,they generally lack the ability to apply the knowledge within the work setting and are often deficient when it comes to working in teams, functioning as critical thinkers, and solving real world problems.

After careful consideration and consultation with stakeholders, the STEAM Education methodology was adopted because its role in “promoting holistic learning and in serving as drivers of innovations” and the fact that “the [STEAM Education] approach to problem solving would encourage greater appreciation for and reliance on the interdependent nature of knowledge when [S]cience and [A]rts intersect”[3].

The Ministry employs the STEAM Education methodology in two ways. Firstly, it treats STEAM Education as an integrative learning approach and methodology in facilitating learning. This approach is focused on helping learners to evolve along their learning journey to become innovative in their thinking and to have embedded within them, a love of learning. These objectives can be achieved by applying the STEAM Education methodology, which promotes experiential, processfocused, project-based learning and allows for creative approaches to problem solving and embraces productive failure (learning from mistakes and iteratively improving outcomes).

The second approach is to view STEAM as an Experiential-Vocational Learning Framework. The aim here is to expose learners to problems that mimic real-life scenarios and the principles and techniques that are used to solve them in work-based environments. By engaging in these types of activities, learners acquire skills and knowledge as well as work-based problem-solving techniques, preparing them for further study or for work.

In an effort to ensure that the NSC was implemented uniformly in all schools, the MOEY developed a set of standards to guide STEAM Education as articulated in the NSC. Box 1 shows the Standards, which are based on the Maryland State Department of Education and International Society for Technology in Education standards. However, the Standards[4], which were developed after the implementation of the NSC, are STEM based and do not consider many of the skills honed through STEAM Education.

For instance, the ISTE standards require that students should become Empowered Learners – taking an active role in achieving their learning goals; Knowledge Constructors – curate resources to create meaningful learning experiences for themselves and others; and Innovative Designers – using technology, guided by a design process, to identify and solve problems by creating new, imaginative solutions [5].

The choice made by the MOEY to use STEM standards to measure the impact of a curriculum based on STEAM Education principles is perhaps a tacit acknowledgment of the limitations of the NSC, in particular as it relates to the use of technology in instruction at all levels. Thus, the standards may have been developed to assess the NSC, which in its current form is designed to account for the lack of resources to implement a complete STEAM Education curriculum.

Box 1. The 8 STEM Standards Governing the NSC Implementation

Core STEM Standards
Learn and Apply Rigorous STEM Contents
Integrate STEM Content
Interpret And Communicate Information from STEM
Engage in Inquiry
Engage in Logical Reasoning
Collaborate as a STEM Team
Apply Technology Strategically
Demonstrate Creativity and Innovation

A curriculum mapping exercise was carried out for this report, with the aim of determining the level of integration of STEM into the curricula of various subjects. Though an assessment of STEAM Education integration would have been ideal, the STEM standards form the core of STEAM Education standards, and so, provide useful, if limited, information on the STEAM Education skills with which learners are being equipped. The first step of the exercise was to provide clear definitions for each of the standards, which would guide the mapping process – Table 2 shows the definitions developed.

[3] Ministry of Education, Youth and Information. (2018). National Standards Curriculum Guide: Grade 1. https://moey.gov.jm/wp-content/uploads/2020/08/MOE-NSC-GRADE-1-Int.-Studies-Language-Math-FINAL.doc. [4] Ministry of Youth, Education and Information Jamaica. (2020). Concept Paper: STEM Education in Jamaica's Education System. Kingston: Ministry of Youth, Education and Information Jamaica, Planning and Development Division.

Table 2. Definitions developed for the MOEY STEM Standards

STEM Standards	Definition
Learn and apply rigorous STEM content	A. Demonstrate an understanding of science, technology, engineering, and mathematics content.
Integrate STEM content	A. Analyse interdisciplinary connections that exist within science, technology, engineering, and mathematics disciplines and other disciplines. B. Apply integrated science, technology, engineering, mathematics content, and other content as appropriate to answer complex questions, to investigate global issues, and to develop solutions for challenges and real-world problems.
Integrate STEM content	A. Identify, analyse, and synthesize appropriate science, technology, engineering, and mathematics information (text, visual, audio, etc.). B. Apply appropriate domain-specific vocabulary when communicating science, technology, engineering, and mathematics content. C. Engage in critical reading and writing of technical information. D. Evaluate and integrate multiple sources of information (e.g.: quantitative data, video, and multimedia) presented in diverse formats. E. Develop an evidence-based opinion or argument. F. Communicate effectively and precisely with others.
Engage in inquiry	A. Ask questions to identify and define global issues, challenges, and real-world problems. B. Conduct research to refine questions and develop new questions.
Engage in logical reasoning	A. Engage in critical thinking. B. Evaluate, select, and apply appropriate systematic approaches (scientific and engineering practices, engineering design process, and/or mathematical practices). C. Apply science, technology, engineering, and mathematics content to construct creative and innovative ideas. D. Analyse the impact of global issues and real-world problems at the local, state, national, and international levels.
Collaborate as a STEM team	A. Identify, analyse, and perform a STEM specific subject matter expert (SME) role. B. Share ideas and work effectively with a STEM focused multidisciplinary team to achieve a common goal. C. Listen and be receptive to ideas of others. D. Analyse career opportunities that exist in a variety of STEM fields relevant to the STEM focused multidisciplinary team's goal.
Apply technology strategically	A. Identify and understand technologies needed to develop solutions to problems or construct answers to complex questions. B. Analyse the limits, risks, and impacts of technology. C. Engage in responsible/ethical use of technology. D. Improve or create new technologies that extend human capability.

The second step was to define a scale for measurement of alignment between the NSC and the STEM Standards. The scale criteria used was a modified version from Wang & Knobloch's research on Levels of STEM Integration through Agriculture, Food and Natural Resources[5]. This scale criteria are based on type of instruction, role of instructor, content knowledge, and role of the student. These criteria give a good idea of the depth of STEM standards and not just the presence of STEM standards within the curriculum.

Table 3. Scoring criteria for determining STEM Integration

Levels of Integration			
	Exploring STEM Integration	Developing STEM Integration	Applying STEM Integration
Role of the Instructor	Instructor gives all direction	Instructor in charge, but students have some freedom to direct learning	Instructor facilitates Student - directed learning
Role of Content Knowledge	Subject content is the primary focus	Subject provides a context for experiential learning	Subject serves as an integrator of learning
Role of Student Thinking	Predominantly constrained, discipline-specific thinking	Limited integrated thinking required	Critical thinking or complex problem-solving encouraged

Early Childhood

The educational experiences of learners should allow for a seamless transition from one level of the education system to the next. With this in mind, the STEM Standards must be replicated in all the curricula, from early childhood to secondary, so that learners are accustomed to the mode of delivery from the start. Building strong foundations in STEM Education at an early age can have major implications for student success. Research has shown the importance of children developing STEM Education skills and knowledge early and the impact of supporting early childhood educators in teaching using the STEM Education methodology[6]. Longitudinal studies by Watts et. al., led them to state: "we find that growth in mathematical ability between age 54 months and first grade is an even stronger predictor of adolescent mathematics achievement"7. Figure 1 shows the level of integration of the STEM standards in the Early Childhood (Age 4 & Age 5) curricula. There is a strong level of STEM content integrated in the Early Childhood curriculum with particular emphasis on science, math, experiments, and graphing. Real-life situations are used to help students understand concepts. In addition, students are exposed to logical reasoning through a variety of sequencing, categorizing, pattern recognition and ordering activities. Creativity is encouraged through projects that reflect real-life and the arts are well represented with song, dance

[5] Knobloch, N. A., & Wang, H.-H. (2018). Levels of STEM Integration through Agriculture, Food, and Natural Resources. Journal of Agricultural Education, 258-277.
[6] Sarama, J. C. (2018). Considerations for STEM education from PreK through grade 3. Retrieved from Cadrek12.org: http://cadrek12.org/resources/considerations-stem-education-prek-through-grade-3.
[7] Tyler W. Watts, G. J.-K. (2014, October 1). What's Past Is Prologue: Relations Between Early Mathematics Knowledge and High School Achievement. Retrieved from Sage Publications: https://doi.org/10.3102%2F0013189X14553660

and art, which give students opportunities to express their individuality. However, there is a lack of problem solving, low levels of inquiry and a lack of innovation opportunities reflected in the curricula. The Standards least well represented in the curricula are, collaborating as a STEM team and interpret and communicate information from STEM. There are only occasional mentions of group work and there appeared to be limited opportunities to develop and present opinions and conclusions. An update to the learning activities to better align with the problem-solving and inquiry areas would provide students with better opportunities in the collaboration and communication areas as well. Teachers would benefit from understanding the role of facilitation and project/ problem-based work to help prepare students for primary school.

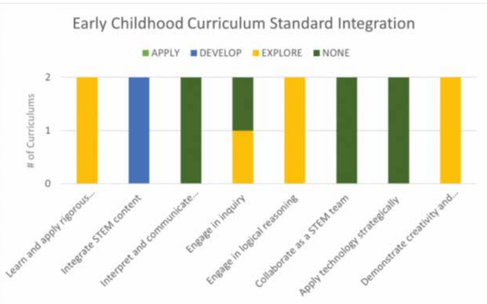


Figure 1. Details of the level of alignment of the Early Childhood Curricula and the STEM Standards.

Kindergarten to Grade 9

Twenty-eight (28) curricula from 17 of the 21 subjects covered under the NSC, between grades 1 and 8, were selected for the mapping exercise. The curricula were reviewed to establish the level of integration of each standard. The level of integration was determined from the frequency and type of learning activities, content, and key skills listed in the NSC. Some of the review was

Figure 2. Overview of STEM Integration Across Curricula

based on a previous mapping report[8]. The results showed a broad integration between the Standards and the NSC curricula as seen in Figure 2. On average, 11% of the curricula were not aligned with the Standards, 68% were aligned at either the exploring or developing level, while 21% were well aligned. Figure 3 shows the details of the curriculum alignment with the Standards.

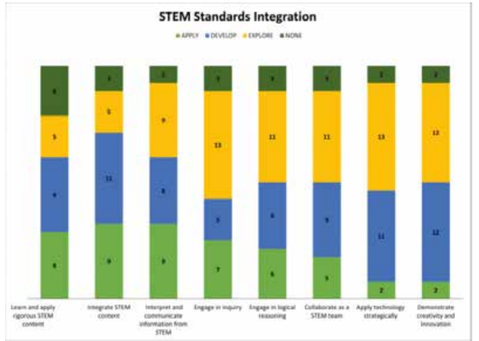


Figure 3. Details of curriculum alignment with the STEM Standards.

STEAM Education Grades 10 - 11

The NSC guides STEAM Education up to, and including, grade 9; beyond that, there is no specific, written curriculum guidance from the MOEY as it relates to STEAM Education. One perspective, which has not been formally articulated, is that these years serve as preparation for, and sitting of external examinations. These examinations do not directly align to the model of assessment recommended by the STEAM Education methodology. Given that these examinations are developed and managed by an external, regional and international bodies, the MOEY has little input into their structure and content. Therefore, schools are given the latitude to prepare students in accordance with the standards and testing methodologies of the testing bodies. Despite this, the MOEY strongly encourages schools to continue with the STEAM Education approach as they prepare their students to sit external examinations. Teachers and administrators are supported in this process by their assigned Education Officers and the Technical and Vocational Education Unit provides guidance on project-based activities for STEAM Education.

The aim of STEAM Education is to prepare students to approach problems with a creative, scientific, collaborative mindset that will lead them to develop innovative solutions through an iterative

[8] Institute of Technological and Educational Research. (2017). National Secondary Curriculum (Jamaica) Mapping Project Report 2017. The Mico University College.

process that allows for flexibility, adaptability and reflection. Thus, the approach can be applied to the process of learning of any subject. However, there are some areas of study that, by their nature, tend to demand these skills and competencies and whose practitioners are more likely to benefit from employing them. These subjects include the individual STEM subjects as well as those digital subjects that are interdisciplinary and include the use of information and communications technologies (ICT) – Table 4 gives a list of these subjects offered at the grade 11 level by CXC[10].

Table 4. A list of subjects for which CXC administers external examinations.

External Examination	Subjects
Caribbean Secondary Education Certificate	Agricultural Science
	Biology
	Chemistry
	Geography
	Human and Social Biology
	Industrial Technology
	Information Technology
	Integrated Science
	Mathematics
	Physics
	Technical Drawing

Following from this, an analysis of the subjects for which students in high school sat external exams. The analysis considered how many of the cohort of students initially registered for these exams[10] and received passing grades in the STEAM Subjects between 2009 and 2020, the results are shown in Figure 4.

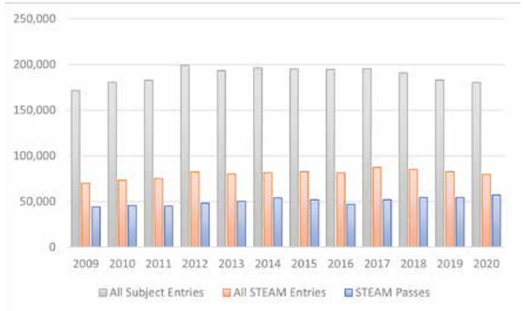


Figure 4. The total number of subject entries in CSEC (2009-2020) alongside the number of subject entries in STEAM Subjects and the number of passes of these subjects.

[9] The list is not exhaustive and does not take into account some of the subjects that are examined by Technical and Vocational Examination councils. The list covers the subjects which are examined by the Caribbean Examinations
Council (CXC), given that the vast majority of students who sit external exams will sit exams set by CXC. [10] The analysis did not account for registrants who failed to sit the exam, it focused on initial interest in STEAM.

On average, 43% of the subject entries for CSEC, for public schools, are for STEAM subjects. At first glance, this may seem to be great news for the STEAM landscape. However, there are two factors that may influence these results: firstly, students registering for external exams in STEAM Subjects enter for multiple STEAM subjects at a time, while most do not register for any. This is borne out in analysis which shows that 85% of Jamaican students do not register to sit any STEM subjects[11]. Secondly, almost two-thirds of the cohort register to sit Mathematics, many of whom do not do any other STEAM Subject. Each year, on average, only 27% of the passes at the CSEC level are in STEAM Subjects.

STEM Academies

In 2014, the Ministry of Education, Youth, and Information developed the concept of the STEM Academy. This initiative was based on an interpretation of STEM an occupational/skills development approach, in the context of expanding access to Technical and Vocational Education and Training (TVET) areas in schools. Eight Technical High Schools and one Traditional High School were selected to pilot the STEM occupational strategy.

It was envisioned that each STEM Academy would have its own structure and curriculum. Additionally, the areas of focus would be determined by local labour market demand. Each school was assigned different TVET programmes as seen in Table 5 below. Students in these academies would be trained in entrepreneurship and would leave job-ready, with marketable skills and the capacity to become entrepreneurs[12]. At the time of conceptualisation, the Arts were seen an addon and STEAM Education was not yet understood to be the integrative methodology that it is.

An important aspect of the proposal was that each Academy was to specialise in an industrial area relevant to region in which the school was found. For example, Sydney Pagon, in St. Elizabeth, was to specialise in Agriculture, while Herbert Morrison, in Montego Bay was to specialise in Business Process Outsourcing. Each school was paired with an industry partner and an advisory committee, consisting of industry leaders, educators and other key stakeholders, to provide guidance and support for each Academy. The initiative aimed to offer students with the opportunity to solve real-world problems, using the STEM Education methodology, in collaboration with industrial partners. This programme is yet to be evaluated to determine its outcomes and impact.

11 Albert Benjamin. (2017). Five-in-four: full STEAM ahead! Jamaica Gleaner. October 10, 2017. https://jamaicagleaner.com/article/commentary/20171011/albert-benjamin-five-four-full-steam-ahead. 12 CONCEPT PAPER: The STEM Academy. (2014). The Ministry of Education, Youth and Information.

Table 5. The STEM Academies and their areas of specialisation.

STEM Academy	PROGRAMME OFFERINGS
Herbert Morrison Technical High	Call/Contact Centre Operations Level 1
Kingston Technical High	• Plumbing Level 1, Renewable Energy, Welding Level 1, • Auto Mechanic Level 1 • Electrical Installation, Motor Vehicle Air Conditioning • System Level 1, Industrial Technology (Building), Mechanical • Engineering, Electrical Installation
St Andrew Technical High	Industrial Electronics Level 1
Dunoon Park Technical High School	Mechanical Engineering Level 1
Vere Technical High School	•Agro food processing l1, Crop production L1, Greenhouse •Technology, Digital Animation
St Mary Technical High School	Crop Production Level 1, Agro Food Processing level 1
Manchester High School	Agricultural Science (Single Award)
Dinthill Technical High School	Small Ruminant Level 1, Crop Production Level 1
Sydney Pagon STEM Academy	Agriculture

STEAM Education: Post-Secondary

The post-secondary STEAM Education landscape in Jamaica is a diverse one, ranging from sixth forms attached to high schools, to technical and vocational training centres to colleges and universities. A formal categorisation by the Jamaica Tertiary Education Commission[13] places Jamaica's 127 higher education providers into one of four categories, namely, Universities (4%), Specialised Institutes and University Colleges (17%), General Higher Education Colleges (38%) and General Providers and Brokers (41%). These institutions provide further opportunities for education and training in the traditional siloed subjects, as well as existing and emerging multidisciplinary areas of study. This section will briefly examine STEAM Education as practised in the post-secondary sector.

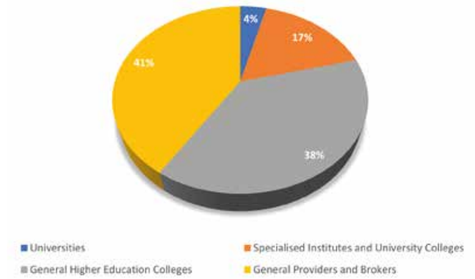


Figure 5. The categories of Higher Education Institutions in Jamaica.
(Source: Jamaica Tertiary Education Commission)

Grades 12 – 13

Many students, upon graduating high school, will attend sixth form – post-secondary institutions attached to high schools – colleges, or community colleges. While sixth forms typically prepare students to sit external examinations, community colleges have a wider range of offerings. In community colleges, some students do enrol for preparation to sit external examinations, others enrol in so-called pre-university programmes. The pre-university programmes take advantage of partnerships with local universities to prepare students to matriculate into university after sitting courses designed and approved by the university and taught by staff at the college.

Sixth forms differ from community colleges in another important aspect. As they are attached to high schools, and as such, are considered a part of the high school, their curricula are guided by the principles of the NSC. As with grades 10 and 11, there is no specific guidance in the NSC

[13] Tertiary-level educational institutions are overseen by both the Jamaica Tertiary Education Commission (jtec.gov.jm) and the University Council of Jamaica. Both institutions perform similar, often overlapping, functions – see the Jamaica Education Transformation Commission's report on education in Jamaica for details.

documentation, but the approach and STEAM Education methodology is recommended by the MOEY and support is made available to the teachers of sixth form subjects.

While opportunities exist for employing the STEAM Education methodology, these years are primarily focused on preparation for external examinations, which, like those sat in grade 11, do not provide for the type of assessment recommended by the STEAM Education methodology. As a result, STEAM Education is not widely embedded. Table 6 shows the STEAM related subjects available for students at the advanced level – the Caribbean Advanced Proficiency Examinations (CAPE) – administered by CXC. Some students opt to do the General Certificate of Education Advanced Level exams.

Table 6. STEAM related subjects available for students at the advanced level

External Examination	Subject
Call/Contact Centre Operations Level 1	Geography
	Agricultural Science
	Animation and Game Design
	Art and Design
	Biology
	Building and Mechanical Engineering
	Chemistry
	Computer Science
	Digital Media
	Electrical and Electronic Technology
	Environmental Science
	Green Engineering
	Information Technology
	Logistics and Supply Chain
	Mathematics
	Physics

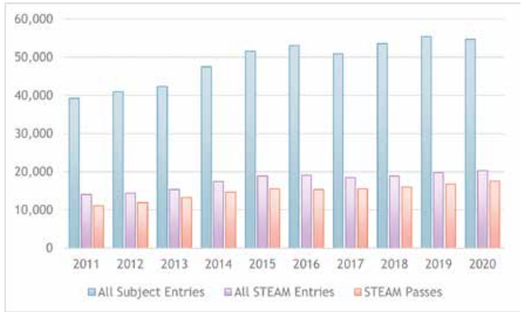


Figure 6. The total number of subject entries in CAPE (2011-2020) alongside the number of subject entries in STEAM Subjects and the number of passes of these subjects

Figure 6 shows the results of an analysis of the number of STEAM subject entries, in public schools, at the CAPE level. The numbers are aggregates of exam results for Unit 1 and Unit 2. On average 36% of the entries at the CAPE level, between 2011 and 2020, were STEAM subjects. As with CSEC, students tend to register for groups of similar subjects – students sitting one STEAM Subject will likely sit many, while most others are unlikely to register for even one. Of the number of registrations to sit exams at the CAPE level, only 30% of the passes were in STEAM Subjects.

TVET

TVET (technical and vocational education and training) refers to the education in technical area and the practise of specialist skills, grounded in science,

that underpin various aspects of society. In Jamaica, TVET is seen as the poor cousin of post-secondary education[14]. This is unfortunate, because TVET has a vast, untapped potential for creating employment opportunities and the overall development of the nation. According to the JETC report, TVET holds the key to tackling unemployment, underemployment as well as a number of socio-economic issues[15].

The main TVET training institution is the Human Employment and Resource Training/National Service Training Agency Trust (HEART/NSTA). In its most recent annual report[16], the institution reported enrolment of 102,270 learners, job placement for 1,327 graduates and 37,190 certifications awarded.

HEART/NSTA has committed to STEM integration but has yet to articulate a policy of employing STEAM Education across the curriculum. However, the Trust recognises the need for STEAM skills and competencies in the workforce and hosts an annual STEAM conference to introduce its learners to emerging careers that require these skills[17].

The Career Advancement Program (CAP) is most recent initiative, managed by the MOEY and funded by the HEART/NSTA, is a training and certification programme for young people that have left formal secondary education without any certification.

Outside of the established training programmes overseen by the Trust, there are informal apprenticeships that account for the training of a large number of the workers in the informal sector, which is estimated to account for between 35 and 44% of the country's GDP[18].

Teachers Colleges, University Colleges and Universities

Despite the obvious need for employing the STEM Education methodology there has been very little focus on STEAM Education in Higher Education[19]. Preparing students for the jobs of tomorrow means enabling them to work in transdisciplinary environments, which leads to the assumption that the approach of training students to specialise in a single discipline is "no longer sufficient for preparing students for the job market or for addressing the complexity of society's problems and needs"[20]. This approach requires a nuanced discussion that is beyond the scope of this report. Nonetheless, the basic premise, that education

[14] Christa Rawkins. (2018). A Global Overview of TVET Teaching and Training: Current Issues, Trends and Recommendations. International Labour Organization and United Nations Educational, Scientific and Cultural Organization. Geneva.
[15] Jamaica Education Transformation Commission. (2021). "The Reform of Education in Jamaica, 2021". https://opm.gov.jm/wp-content/uploads/flipbook/jetc-reform-of-education-in-jamaica-2021/
[16] HEART/NSTA. (2021). HEART/NSTA 2020-2021 Annual Report.
[17] Jamaica Observer. (2020). HEART trainees attend STEAM conference in National Career Awareness Week. https://www.jamaicaobserver.com/career-education/heart-trainees-attend-steam-conference-in-national-careerawareness-week/
[18] Inter-American Development Bank. (2017). Estimating the Size of the Informal Economy in Caribbean States. Accessed August 8, 2022. https://publications.iadb.org/en/estimating-size-informal-economy-caribbean-states

should be multidisciplinary and integrative, goes without saying.

The quest for STEAM Education to permeate tertiary education begins in the teacher training institutions, as it is well understood that the single most important factor determining academic performance is the quality of teachers and teaching practices. A snapshot taken in 2016 showed that there were 27 public and private institutions offering teacher education programmes at the Post Diploma, undergraduate and graduate levels in Jamaica[21]. While there is no centralised approach to applying STEAM Education methodologies across their curricula, there is a broad commitment to training the nation's teachers using this approach[22]. These efforts are being supported by the MOEY, which has a "broad embrace of STEAM education"[23].

In addition to preparing pre-service teachers, some teacher training institutions are providing access to training in STEAM Education methodology to in-service teachers. Through professional development activities, to date, over five hundred (500) primary and secondary in-service teachers/ instructors have been trained to implement the integrative STEAM Methodology.

At the University level there is need to produce graduates with particular skills that will see them involved in the economy at various levels and in various industries. By its very nature, the world of work requires individual skills, specific to each industry. Although the jobs of today, and more so tomorrow, require an interdisciplinary (even transdisciplinary) approach to problem solving, there is clearly the need for discipline-specific knowledge on the part of each team member. This, therefore, means that STEAM Education is just as important in the higher education domain as it is in the primary and secondary space. Unlike these other sectors, higher education institutions, given their differing focuses and approaches, do not have a cohesive national STEAM Education curriculum or even an agreed approach to employing the STEAM Education methodology.

A recent project in the European Union has proposed an approach to implementing STEAM Education at the higher education level[24]. The authors propose that the approach should involve:

- putting the Arts and Sciences on an equal fitting

[19] Carter, C. E., Barnett, H., Burns, K., Cohen, N., Durall, E., Lordick, D., ... & Ussher, S. (2021). Defining STEAM Approaches for Higher Education. European Journal of STEM Education, 6(1), 13.
[20] Ibid.
[21] George, N., Henry-Wilson, M., & Plunkett, N. (2016). A case study in Jamaica's reform of teacher education: Preparing teachers for the 21st century classroom. ICET 2016 60th World Assembly 60th Yearbook of Teacher Education.
[22] Albert Benjamin. (2017). Five-in-four: full STEAM ahead! Jamaica Gleaner. October 10, 2017. https://jamaicagleaner. com/article/commentary/20171011/albert-benjamin-five-four-full-steam-ahead.
[23] Chris Patterson. (2022). Education Ministry Implements Initiatives to Boost STEAM Learning. Jamaica Information Service. https://jis.gov.jm/education-ministry-implements-initiatives-to-boost-steam-learning-jis/
[24] Carter, C. E., Barnett, H., Burns, K., Cohen, N., Durall, E., Lordick, D., ... & Ussher, S. (2021). Defining STEAM Approaches for Higher Education. European Journal of STEM Education, 6(1), 13.

- creating a space that is process-driven, as opposed to outcome driven
- creating explicit opportunities for collaboration with diverse groups
- establishing a mindset of openness, flexibility, re flection, experimentation and curiosity
- considering modes of assessment that support pro totyping and making
- developing competencies of critical thinking, crea tivity and communication

The mission statements of all Jamaican universities speak to some aspects of the ideal STEAM University, as articulated by the attributes above. However, all are still highly siloed, with the majority of the courses still lacking in opportunities to collaborate across disciplines and assessment following established norms – focused on the outcome and not the process of arriving at a solution.

One of the undervalued benefits of university teaching is the incorporation of the lecturer's own research into their teaching. Teaching and research are often seen as completely separate domains that constrain one or the other because of their competing demands. However, is has been shown that research can impact teaching, both in principle and in practise25. Witnessing students gain an appreciation and excitement for their field of expertise, can motivate a researcher and even inspire them to explore new avenues of research. By showing students how research isconducted it opens up avenues students making the transition into critical thinking. Bringing research into the classroom helps to show the translation of fundamental principles into real-world problem solving[26].

Involving undergraduate students in research follows the constructivist pedagogical approach espoused by the STEAM Education methodology. In many instances, this involvement puts students in contact with external individuals and companies with real-world problems to solve, which gives the students the opportunity to see research in action and to be, themselves, actively involved in the creative, collaborative problem-solving process This has the potential to retain more students in the discipline and to produce more engaged practitioners. While this is true for most every discipline, it is particularly relevant for STEAM-related subjects, given the need to produce more skilled graduates. As a group of researchers put it, "The solution to the demand for STEM workers must include recognizing reciprocity between research and teaching." [27].

STEAM Education: In Industry

Jamaica's preparations for the achievement of Goals 1 and 3 of its National Plan - Vision 2030 are expected to result in the emergence of a robust, technology -driven, globally competitive economy. However, as we strive to meet the requirements of the Fourth Industrial Revolution, we must contemplate the uncertainties about the composition of the future la-

bour market and the current, and anticipated, dramatic shifts in the nature of work and the imperatives of the type of training and education which will be required to meet these new demands.

[25] Prince, M. J., Felder, R. M., & Brent, R. (2007). Does faculty research improve undergraduate teaching? An analysis
of existing and potential synergies. Journal of engineering education, 96(4), 283-294.
[26] Feller, M. B. (2018). The value of undergraduate teaching for research scientists. Neuron, 99(6), 1113-1115.
[27] Gregg-Jolly, L. A., Kington, R., Lopatto, D., & Swartz, J. E. (2011). Benefits of intertwining teaching and research.
Science, 331(6017), 532.

Figure 7. Jamaica's Vision 2030, Goals 1 and 3 and their outcomes.

The emphasis on STEAM is on the increase globally, given the wide-ranging and future-focused careers emerging. Many analysts and experts point to jobs such as data analysts and scientists, software and applications developers, e-commerce and social media specialists, AI and machine learning specialists, big data specialists, process automation experts, robotics engineers and blockchain specialists as the jobs of the future. However, these are the jobs of the current generation. It has been proposed by the World Economic Forum, that 65% of the jobs of the future do not exist today[28]. Thus, the workers of tomorrow must be trained using the STEAM Education methodology, in order to be flexible enough to meet the technical and creative demands of these multidisciplinary careers of the future.

The Vision 2030-National Development Plan reflected the recognition of the increased demands being placed on Jamaica to compete in the digital age. It is against this backdrop that this review attempts to provide contextually relevant information on Jamaica's actual and potential STEAM labour market, with a view to informing education planning to meet emergent needs.

The STEAM Labour Force

The 2010 Growth Inducement Strategy piloted by the Planning Institute of Jamaica (PIOJ) in consultation with 27 Ministries and Departments, and 22 private sector firms (to include the Private Sector Organisation of Jamaica (PSOJ), the Jamaica Manufacturing Association and the Small Business Association) signalled broad agreement and support around the articulation of areas targeted for growth of the economy. The targeted high growth areas most aligned with STEAM competencies are Agriculture/Agribusiness Construction; Manufacturing; Information, Communicationand Technology (ICT); Business Process Outsourcing (BPO); and Creative Industries[29].

[28] World Economic Forum. (2016). The future of jobs: Employment, skills and workforce strategy for the fourth industrial
revolution. Global Challenge Insight Report.
[29] Planning Institute of Jamaica. (2018). An Assessment of the Implementation and Impact of the Government of
Jamaica's Growth Inducement Strategy: A Summary. Retrieved from Planning Institute of Jamaica Reports:
https://www.pioj.gov.jm/product/an-assessment-of-the-implementation-and-impact-of-the-government-of-jamaicas-
growth-inducement-strategy-a-summary/

Table 7 shows the estimated size of the STEAM-related labour force[30] as compiled, using industry data reported, by Statistical Institute of Jamaica (STATIN). A composite was created to represent Engineering to include Construction, Manufacturing, Mining and Quarrying, and Real Estate. Similarly, Mathematics is represented by Finance and Insurance Activities and Technology is expanded to include Transport and Storage, Electricity and Gas. The BPO industry is also not specifically referenced by STATIN, therefore figures drawn directly from Ministry data are used. The data reveals that as of October 2021, 779,000 employees are estimated to exist within the STEAM field, approximately 59% of the total labour force. This gives the impression that the STEAM workforce is large; however, the number accounts for skilled and non-skilled labour within an industry. STATIN does not provide data disaggregated by skill level and industry; thus, it is difficult to say how many of these workers are skilled and trained in STEAM subjects. Females account for only 32.5%; the Arts and Mathematics are the only STEAM areas in which females significantly dominate.

Table 7. Estimated Size of the STEAM Labour Market

CLUSTER	Industry	Total (Oct 2021)	Male	Female	Male Industry Total (%)	Female Industry Total (%)
Science	Agriculture, Hunting, Forestry and Fisheries	192,300	140,200	52,100	72%	28%
Technology	Transport and Storage Information and Communication Electricity Gas and Water supply BPO	61,200 13,600 10,000 44,000	54,400 7,300 7,500	6,800 6,300 2,500	82%	18%
Engineering	Mining and Quarrying Construction Manufacturing Real Estate and Other Business Services	3,800 113,900 72,100 130,500	3,500 109,400 51,000 61,600	300 2700 21,100 68,900	70%	30%
Arts	Arts, Entertainment, Recreation and Other Services	111,500	37,100	74,400	33%	67%
Mathematics	Financial and Insurance Activities	26,100	7,800	18,300	30%	70%
	TOTAL	779,000	479,800	253,400		

Private Sector STEAM Initiatives[31]

A number of private sector companies and foundations have caught the vision and seen the promise of STEAM Education approaches to learning, and as such, have made an effort to support STEAM and STEAM-related projects and initiatives. A number of them are highlighted below.

As a part of their outreach activities over the last five years the MUSSON foundation has collaborated with the technology social enterprise called Halls of Learning to host the annual Lego "Yuh Mind" Outreach Day activities. In July of 2019 more than 250 children of all ages were sponsored to participate in robotics and coding activities.

The Seprod Foundation has been providing scholarships for over 30 years and most recently began to play a role in bringing innovative experiences to children in Jamaica. Major projects include the World Robot Olympiad (WRO), the Hour of Code, Jamaican Girls Coding, Scratch Day, and professional development opportunities for teachers in technology. One of the more recent STEM projects involved a collaboration with Halls of Learning, to sponsor the first Robotics Competition in Jamaica.

[30] These figures are national samples of all employees within the STEAM related industries and are not specific to workers with STEAM qualifications.

[31] This list is not exhaustive and represents only a few of the initiatives undertaken by private sector interests. Omissions should not be taken as an attempt to diminish the stellar work of these organisations.

The Digicel Foundation has been involved with STEAM-related projects for many years. One of the notable initiatives is the construction of a STEAM laboratory for teacher training at the Bethlehem Moravian College.

A consortium of private sector companies along with public sector, academic and not-for-profit organisations have come together to form the Jamaica Stem for Growth Taskforce. This initiative, led by CARIMED, has a vision to "Create a vision of Jamaica as a STEM nation and to enlist [the private sector's] input and support for practical steps needed to make this a reality". One of the major long-term initiatives of the Taskforce, is the development of a National STEAM Centre at the Mico University College, with 20 satellite centres island wide. The Centre will serve to provide STEAM training and experiences for student teachers, primary and secondary students and the general public – a major initiative in the creation of a STEAM ecosystem in Jamaica.

The National Baking Company Foundation has partnered with the University of the West Indies to fund an ambitious fellowship programme to enhance the quality and quantity of STEM teachers in Jamaica. The initiative, BOOST (Building Out Our STEM Teachers). The programme aims to place the brightest STEM graduates into the classrooms of, primarily, non-traditional high schools for up to three years. These students are offered a scholarship for each year of teaching and a performance-based

incentive for demonstrated excellence. Since its inception, a number of partners have joined the programme, including, The Ministry of Education and Youth, Mico University College, Digicel Foundation, Jamaica Teaching Council, National Education Inspectorate, and American Friends of Jamaica. Most recently, the NCB Foundation has come onboard to push the BOOST programme toward being a STEAM initiative by supporting Fellows who have studied digital subjects, such as IT, Digital Media, Animation and Game Design.

STEAM Education: In The Community

An important part of the ecosystem is the community. It is in the community where approaches to life and mindsets are first informed. If community-based problems are solved, community members can be convinced of the value of STEAM Education. If members of the community get involved in STEAM Education, them children can be inspired. There is a vibrant community-based STEAM Education landscape, much of it informal, which will be briefly discussed.

The social sector in Jamaica is involved in STEAM Education. One such organisation, among many, is STEAM House Network, which works as a social enterprise to expose children from lowto middle-income communities to the concepts of STEAM Education through integrated projectbased learning. STEAM House recently partnered with the Robeson American Center, housed at the United States Embassy, to develop a Makers STEAM Club to serve students from primary school all the way through tertiary education.

Individuals at times make contributions to STEAM Education that go beyond the support of one or two individuals that is common in most communities. Of note is the recent donation of an entire

STEAM Lab to Jamaica College, by alumnus, Dr. Joseph Tait. The Lab is the centrepiece of the STEAM Infusion Project being carried out at Jamaica College. Other community-based STEAM Education efforts can be seen in the TVET training carried on in the form of apprenticeship programmes. These are often informal training programmes undertaken by large and small business as a way to help community members to learn a skill that they can employ to support themselves and their families.

III. The Jamaican STEAM Education Gaps

The gaps in STEAM Education were identified through a mixture of stakeholder surveys and desk research. The *Education Readiness Assessment* desk review was done as a part of this project, to determine the Education Sector attitudes and disposition towards STEAM both in Jamaica. The study was focused on ninety-three (93) randomly and purposively selected primary and secondary schools located across the seven regions of the Ministry of Education and encompassing all fourteen parishes to
ascertain their attitudes, disposition, and readiness for STEAM education, as well as an assessment of their ICT needs. Only 219 educators from 47 schools responded. Though this fell below the targeted total for generalisation meaningful trends can be ascertained because of the representativeness of the data. Additionally, seventy (70) business enterprises were purposively selected for industry growth needs assessment surveys.

The desk research revealed that the implementation of an effective STEM program faces several challenges. Some challenges were common across countries that sought to implement a STEAM Education programme. Among these challenges were additional preparation time for teachers, the need for additional resources, inventory storage, and institutional readiness. Additionally, teachers struggled to find real-life contexts for abstract topics in mathematics and other subjects. Insufficient comprehension of STEM concepts, limitation of time provided to carry out STEAM projects, lack of funding, and the lack of facilities and resources were also reported as major obstacles.

STEAM Education Gaps: Early Childhood – Grade 11

The responses of educators and support staff to some of the survey questions revealed many of the gaps that currently exist in the pre-tertiary sector.

Lack of understanding of STEAM Education:
Fifty-one percent (51%) of the responding teachers said that they understood STEAM to be subject specific. This revealed that at a basic level, there was a lack of understanding of what STEAM Education is meant to be. This is clearly a barrier to them employing the STEAM Education methodology in their classrooms.

Inadequate training in STEM Education:
Despite the lack of understanding of STEAM Education,

more than 85% of the respondents reported being satisfied with the training received. There is clearly a disconnect, which points to a lack of appropriate training.

Lack of training in use of ICT:
Approximately 40% of employed ICT Lab technicians were either self-trained or untrained; hence technical support is not assured. Moreover, only 38% of the teachers were deemed trained and competent in the use of ICT resources. Notably, 46% were considered competent but not formally trained.

Lack of appropriate infrastructure and equipment:
In reporting the current ICT infrastructure, 86.6% were deemed inadequate or obsolete. Specific technologies were also seen as primarily nadequate, obsolete, or non-existent. Notably, specific STEAM Education resources such as robotics kits, virtual reality, and 3D printers were non-existent.Only 24% of primary as well as secondary schools reported that they had adequate tablets and only 8% reported that they had STEM kits. This is despite the emphasis placed on the use of ICT in the NSC.

Early Childhood

Lack of adequately trained staff:
It has been shown that more than 64% of staff in the early childhood sector are trained below the diploma level, with as many as 12% having been trained only to the secondary level[32].

Lack of early exposure to STEAM-related activities and concepts:
Children in early childhood institutions were not likely to be exposed to creative development, conflict resolution, scientific activities, or technology. Just over half of the institutions met the standard for exposure to mathematics and cognitive development[33].

Lack of funding:
A recent study by the World Bank showed that early childhood education was woefully underfunded[34].

Kindergarten to Grade 11

Lack of teachers adequately trained in STEM or the STEAM Education Methodology:
Many teachers struggle with teaching individual STEM subjects and using STEAM Education principles in their lessons. As a result, students themselves struggle with fundamental concepts and are left without the requisite knowledge, skills and attitude to make the most of opportunities for work or further education.

Lack of a link between educational material and careers:
A clearer focus on careers might enhance the curriculum and standards, potentially providing a stronger correlation between what students are learning in school and future employment.

STEAM Education Gaps: Post-Secondary

Lack of adequate teacher training in STEAM Education:
The respondents to the surveys showed strong agreement on the need for strengthening the training of teachers in STEAM Education methodologies at all levels of the curriculum. The dominant inhibitor that was noted by most interviewees was teacher quality followed by a lack of resources. One respondent noted that “too many teachers have little science knowledge[34]”. Another claimed that too many teachers lacked the training in STEM subjects.

Lack of resources:
The tertiary sector suffers from a lack of investment in infrastructure. Given the need for lab equipment, laboratories and access to reliable utility supplies and access to the internet, these institutions generally have higher infrastructure demands than the rest of the education sector. It is difficult to conduct research and practical teaching with “crumbling resources and obsolete equipment and laboratories (particularly for institutions with STEAM focus).”[35].

Lack of funding for research:
Given the link made earlier, between research and quality teaching in the tertiary sector, it is important to fund research (both fundamental and applied). Research is known to inform practice, especially in STEAM-related disciplines, thus it is imperative that funding is made available for research at the tertiary level

STEAM Education Gaps: In Industry

Lack of investment in STEAM:
Despite the admirable work of many corporations, there is a need to build further partnerships with the MOEY and educational institutions. Corporate respondents pointed to the need to provide more STE[A]M scholarships, materials, and resources to gifted teachers and students, as well as to launch a marketing campaign on the relevance of STE[A]M fields to growth and development.

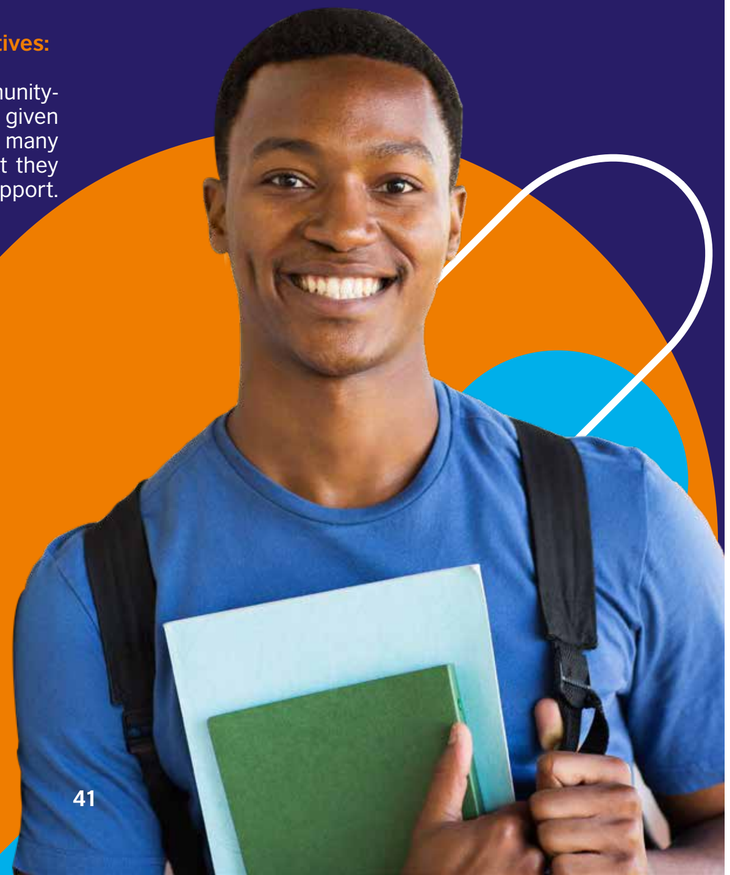
Lack of investment in research and development:
Jamaica’s expenditure on research and development, as a percentage of GDP is 0.03%[36]. At this level, the implication is that there is vast room for innovation and collaboration with tertiary institutions on STEAM-related projects.

[32] Jamaica Education Transformation Commission. (2021). “The Reform of Education in Jamaica, 2021”. https://opm.gov.jm/wp-content/uploads/flipbook/jetc-reform-of-education-in-jamaica-2021/
[33] Ibid.
[34] World Bank. (2022). Public Expenditure Review of the Education Sector in Jamaica (English). Washington, D.C.: WorldBankGrouphttp://documents.worldbank.org/crated/en/099925003242215282/P17348204b87d40e0b6d60ef968189869b
[35] Jamaica Education Transformation Commission. (2021). “The Reform of Education in Jamaica, 2021”. https://opm.gov.jm/wp-content/uploads/flipbook/jetc-reform-of-education-in-jamaica-2021/

STEAM Education Gaps: In the Community

Lack of support for community-based initiatives:

There are a few community-based, or community-focused institutions that are well funded and given technical and administrative support. However, many more exist that are unable to have the impact they could, because of a lack of financial and other support.



[36] Barrett, A. P., Tennant, V. M., Cooke, K. O., Kahwa, I., Ivey, P., & Clarke, S. S., 2016.Reforming Jamaica's National Systems of Innovation. Technical Report, Report #1, Labour Market Reform Commission, Technology, Innovation & Productivity Committee, Public Sector Productivity Working Group, DOI: 10.13140/RG.2.1.2384.1685

STEM Education Gaps: Gender Accessibility

Girls outperform boys at all education levels:

Girls outperform boys at all levels of the education system. At the University of the West Indies, females account for approximately 67% of the enrolled student body – except in Engineering, the Built Environment and Computer Science where males dominate, in terms of numbers,. This translates into the Industrial space, where men are more prevalent than women, largely driven by the lack of women in Engineering, Construction, Transportation and Agriculture, Hunting, Forestry and Fisheries. There is a challenge to better engage males in school (including the post-secondary level) as well as a gap where females are not participating in particular STEAM-related areas.

STEM Education Gaps: Assessment of STEAM Education Curricula

Appropriate Assessment of STEAM Education is challenging:

In many instances, appropriate assessment is time-consuming and can be expensive., thus teachers may be unwilling, or unable to engage in the prescribed form of assessment. Additionally, beyond the NSC, high schools are forced to teach to the test, as assessment is controlled by external entities and follows traditional approaches.

IV. Full STEAM Ahead – The Path Forward

Recommendations

The Government of Jamaica has continued its efforts to create an enabling environment for economic growth and employment creation. As such, several growth sectors have been identified to generate employment opportunities. These include Business Process Outsourcing, Tourism, Creative industries – (Animation and Film), Construction, Manufacturing, Energy and Mining (MEM), Cyber Security, Agriculture, Robotics and Gaming. These sectors will require a skilled workforce that is able to 'create' not just 'use' technology. These same skills will underpin the delivery of public services, including healthcare, education, emergency services and national defence. Countries managing to show significant economic growth tend to emphasize a STEM culture of learning as well as deliberate strategies to increase output in STEM subjects.

In 2019 the Prime Minister explicitly pointed to the need for STEM schools if Jamaica is to be an agile, innovative, and creative nation, citing STEM capability and digital disruption as core to thistransition. Business leaders are also prioritizing STEM skills such as computational thinking and coding as essential to the jobs of the future. However, despite these pronouncements a scan of the status of STEM in Jamaica reveals initiatives are largely fragmented and outcomes unspecified. With exception to primary education and elements in the early years curricula there is lack of clarity regarding a cohesive STEAM agenda across the pre-tertiary curriculum. These issues along with teacher apathy and even confusion as to their role in STEAM education further confound the situation.

The recommendations from this review of Jamaica's STEAM Education landscape all surround three basic actions: increased training, increased funding, and increased collaboration.

Increased Training

The call for increased training is aimed primarily at teachers. The challenges that teachers face in delivering the STEAM Education curriculum are many and varied, but the survey of practitioners conducted for this report makes it clear that there are significant gaps in the training of both preservice and in-service teachers. Teachers indicated that they thought their training in STEAM

Education was adequate, and yet they struggled to articulate the purpose of STEAM Education. This suggests a deficit in their initial training. One possible approach to remedying this is to more actively employ the STEAM Education methodology across the curriculum, and not in courses that are designed to teach about STEAM Education. If teachers are immersed in a teaching and learning environment that completely integrates STEAM Education principles, including assessment, they are more likely to practice it in their own classrooms upon graduation.

For many in-service teachers, the concept of STEAM Education is still quite foreign, as they were never exposed to it during their training. This is where continual professional development will make a difference. To develop and maximize STEAM Education skills, it is fundamental that educators are exposed to leading-edge resources and research that are in alignment with the STEAM standards. Educators must be exposed to training that will influence them to rethink, reimagine and reinvent teaching and learning. In addition, professional development is integral in the successful implementation of integrated STEAM Education.

Based on the curriculum mapping activities, educators have a working understanding of the standards. For them to maximize their effectiveness in the classroom, it is crucial that they are exposed to professional development and mentorship. Addressing professional development of teachers is one way to help ensure the curriculum is implemented successfully. Teaching STEM infused curriculums requires strong skills in problem and project-based learning as well as understanding how to be a facilitator in the classroom. It requires a shift in pedagogy to ensure student ownership of learning and the integration of real-world connections between the content and the learner. Therefore, professional development in the areas of STEM learning, problem-based learning, project-based learning, and the teacher as facilitator are essential.

As the importance of professional development is understood, it is important that the learning environment be such that educators have the freedom to attend appropriate courses and seminars. This points to one of the other groups that need training – administrators. Principals, Ministry officials (Education Officers, for example) need to be trained in the integration of STEAM Education from the perspective of an administrator. What changes need to be made to budgets, to timetables, to teacher responsibilities and accommodations? Administrators are anxious for the gains promised by STEAM Education, but they have not all been made aware of the sacrifices that need to be made in order to realise these gains.

Finally, support and technical staff need also to be trained in STEM Education. Providing the right environment, procuring the appropriate hardware, software, educational materials, is a significant responsibility that can significantly impact the

success of a STEAM Education integration project. The proposed National STEAM Centre can play an integral role in providing training in STEAM Education for all stakeholder groups.

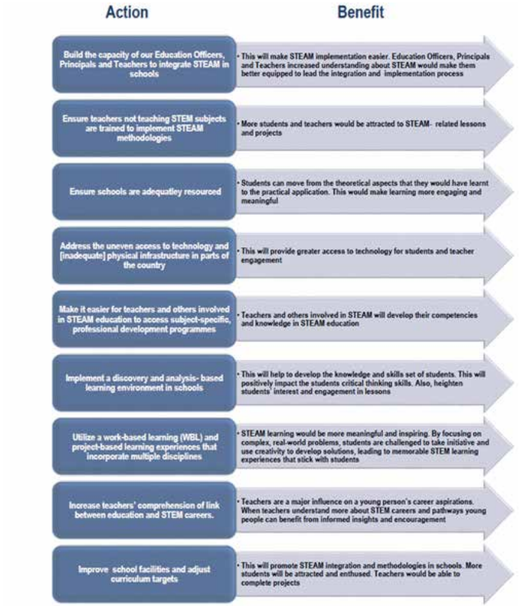


Figure 8. Actions that can be taken to enhance STEAM Education integration and the attendant benefits.

Increased Funding

Any suggestion to increase funding, in an economy that is not growing at high enough rates to support increases, is likely to be met with scepticism. However, the cost of inaction will certainly be greater. Spending on education is one of the most cost-effective means of securing long-term growth and development of an economy[37]. Funding for education should cover all levels of education for the greatest gain; poor countries need significant funding in primary and secondary education to boost human capital and significantly reduce poverty, while industrialised countries require significant investment in tertiary education in order to increase economic growth38. It should be noted, then, that economic growth and development are capped when there is little to no focus on tertiary education. Universal primary education and broad access to secondary education alone will not lead to the levels of growth achieved by industrialised nations, as most of the innovation and industrial transformation takes place in countries with high levels of tertiary graduates39.

In recent times, there have been studies calling for a reallocation of resources from tertiary education to fund early-childhood education in Jamaica40,41. These reports point to the established benefits of quality of early childhood for overall learner development and future learning. However, the call for reducing funding to tertiary education maybe somewhat short-sighted, given the overall goals of the country as articulated in the Vision 2030 goals (see Figure 7). If Jamaica is to develop in accordance with its stated goals, it must increase spending at all levels of education.

Jamaica gets high marks for its spending on education, which compares favourably with countries in the region and even the OECD. Nonetheless, Jamaica's spending on education, as a percentage of GDP, is falling; from a level of 6% between 2008 and 2014 to approximately 5% in recent years, this while actual spending on education is increasing[42]. The implication here, is that spending on education could be further increased.

The obvious question is how to fund this increased spending. The first approach is simply for government to increase funding to education. This will, of course, will require additional borrowing, which may be met with resistance. However, it is worth noting that public spending on education reaps great rewards, with research showing that for every US$1 spent on education, between US$10 and US$15 in economic growth can be realised[43].

Local public-private partnerships are a useful way to increase funding for education. By putting in place a systematic mechanism to engage local businesses,

37 C. Grant. (2017). The Contribution of Education to Economic Growth. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies.
38 Ibid.

the government could creatively fund some aspects of education at a community-based level. If, for instance, partners were engaged to fund the installation of alternative energy and water harvesting systems, this would reduce recurrent costs and free up funds for core education spending. This type of approach would have the added benefit of students being engaged in STEAM Education through project-based learning, as they could play active roles in the planning, design and implementation of the projects.
Businesses would also be playing a part in their own sustainability, as they would be building local capacity and ensuring that they will have a pool of skilled local youth to fill roles within their organisations.

Increased Collaboration

The most striking aspect of the gap analysis is the lack of collaboration within the STEAM ecosystem. There is a lot of work being done by individuals and organisations, but much of it is done
in a disjointed manner. Corporation among members of the ecosystem is vital, given the value and reach of each member. Working together to form a true STEAM ecosystem (a network of interconnected organisations, systems and approaches all geared toward enhancing STEAM Education) will bring tremendous benefits to each member and ultimately to the country. Becoming a part of the STEAM ecosystem is not an altruistic endeavour, but one of enlightened self-interest.

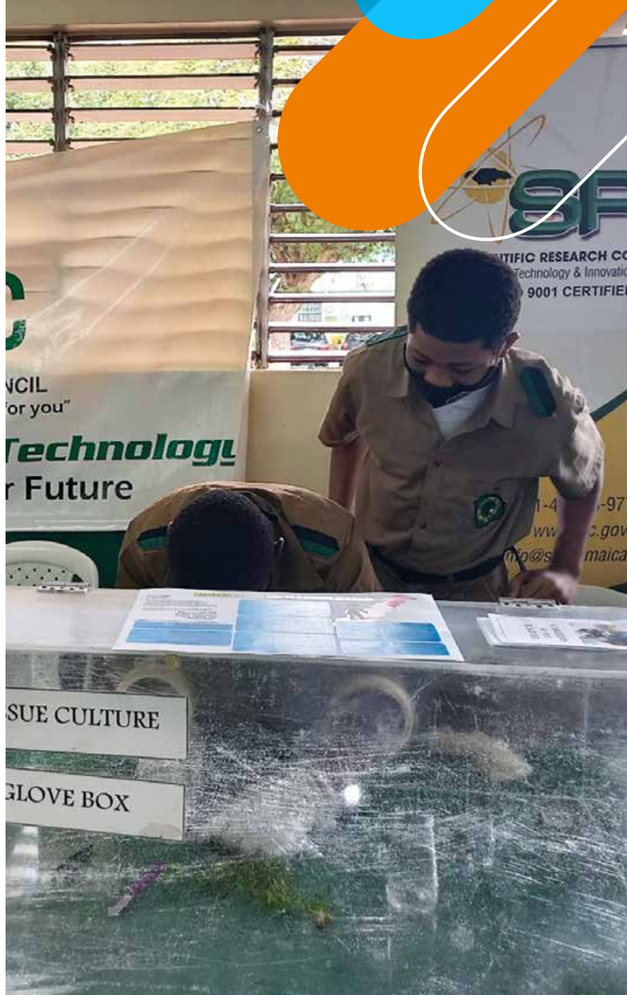
The first step is for stakeholders to think of STEAM Education outside of the classroom. When learners – in particular, those in the K-13 years – see similar standards, hear similar language used and identify similar processes outside of the classroom, then they make stronger connections between the ideas explored in school and their application in the rest of society. Science clubs, robotics clubs, greater university-high school engagement, after school activities hosted by community-based organisations,

[39] G. Larson, N. Loayza, M. Woolcock (2016) The Middle-Income Trap: Myth or Reality? Research Policy Briefs From
the World Bank Malaysia Hub. http://documents.worldbank.org/curated/en/965511468194956837/pdf/104230
-REVISED-Revised-RPB-1-Middle-Income-Trap.pdf.
[40] Jamaica Education Transformation Commission. (2021). "The Reform of Education in Jamaica, 2021".
https://opm.gov.jm/wp-content/uploads/flipbook/jetc-reform-of-education-in-jamaica-2021/
[41] World Bank. (2022). Public Expenditure Review of the Education Sector in Jamaica (English). Washington, D.C.:
World Bank Group. http://documents.worldbank.org/curated/en/099925003242215282/P17348204b87d40e0b6
d60ef968189869b
[42] Ibid.
[43] UNESCO. (2012). Youth and skills. Putting education to work (Global Monitoring Report). Paris: UNESCO

science fairs sponsored by businesses, job fairs with a wide variety of career options presented by a variety of employers, publicly accessible maker spaces, and science programmes on television are just a few of the activities that could help students make the links that STEM Education promotes.

Finally, empowering parents, guardians and community organisations to participate in the education of all learners, is an important step forward in employing the STEAM Education methodology and fostering a love of learning and creating a deeper practical understanding of scientific principles and processes. This can be achieved through PTA group STEAM workshops, church and community centre weekend and summer engagement. By making a concerted effort to create a true STEAM ecosystem, there are myriad possibilities for unlocking the potential that exists for the growth in education, innovation, social stability and national development.

Figure 9 outlines a possible approach to developing a STEAM Ecosystem in Jamaica. It places,at the proposed National STEAM Centre in a coordinating role, bringing together key stakeholders and making connections for efficient deployment of resources and initiatives. In this model, stakeholders are seen as both producers and consumers of STEAM content, the skills derived from STEAM Education and the attendant benefits of having a robust STEAM ecosystem.



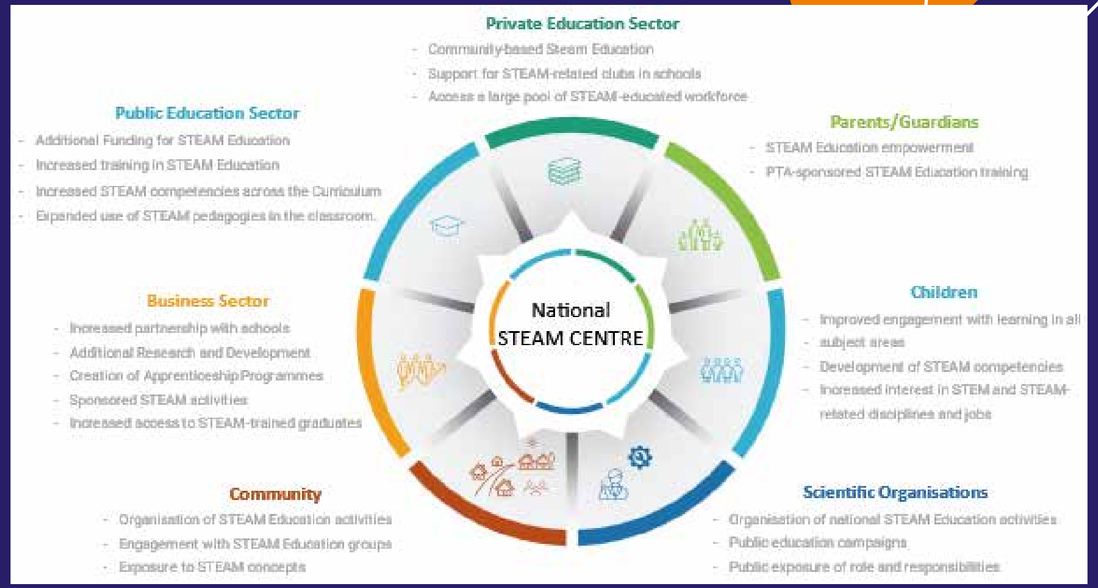


Figure 9. A model for creating a STEAM Ecosystem with a National STEAM Centre as the central coordinating body.

V. Policy Brief

PURPOSE

The National STEAM Education policy seeks to streamline the elements of the National STEAM Education Ecosystem including curricula. This will allow education and industry stakeholders to work in a cohesive and efficient manner to make Jamaica into a 21st century STEM economy. This policy will serve as the basis to strengthen, grow, and shape the ecosystem for STEAM Education in Jamaica through ensuring access, equity, and inclusivity. The policy will address the following challenges:

1. Ensure a cohesive approach to integrative STEAM education through strategic curriculum design.
2. Facilitate the development of a nodal STEAM centre for the coordination of all activities related to the development of a national STEAM culture.
3. Formalise the linkages between schools, industry, private STEAM Education partners, national scientific organisations, community-based organisations, parents/guardians and students.
4. Introduce a formal apprenticeship system

POLICY OBJECTIVES

Recognising the imperative of ensuring deliberate linkages between STEAM education and Jamaica's future economic development and the role of government in setting the policy framework to facilitate streamlined linkages among key national stakeholder groups, the following policy objectives are recommended:

5. To establish a national nodal centre for the coordination of all activities related to developing a STEAM culture in Jamaica.
6. To advance a cohesive national Integrative STEAM Education curriculum throughout the pre-tertiary phase of education.
7. Work with external examination bodies to allow for the development of assessments commensurate with the STEAM Education methodology.
8. The adoption of international STEAM Education standards.
9. To propose a framework for integration of the STEAM Education methodology across curricula in the tertiary sector
10. To formalise linkages between participating stakeholder groups to maintain relevance and to promote continuous innovation.

11. To establish a national nodal centre for the coordination of all activities related to developing a STEAM culture in Jamaica.

12. To advance a cohesive national Integrative STEAM Education curriculum throughout the pre-tertiary phase of education.

13. Work with external examination bodies to allow for the development of assessments commensurate with the STEAM Education methodology.

14. The adoption of international STEAM Education standards.

15. To propose a framework for integration of the STEAM Education methodology across curricula in the tertiary sector

16. To formalise linkages between participating stakeholder groups to maintain relevance and to promote continuous innovation.

17. To develop standards for schools to be certified as STEAM academies.

18. To develop a national education campaign promoting the value of STEAM Education to the development of the economy.

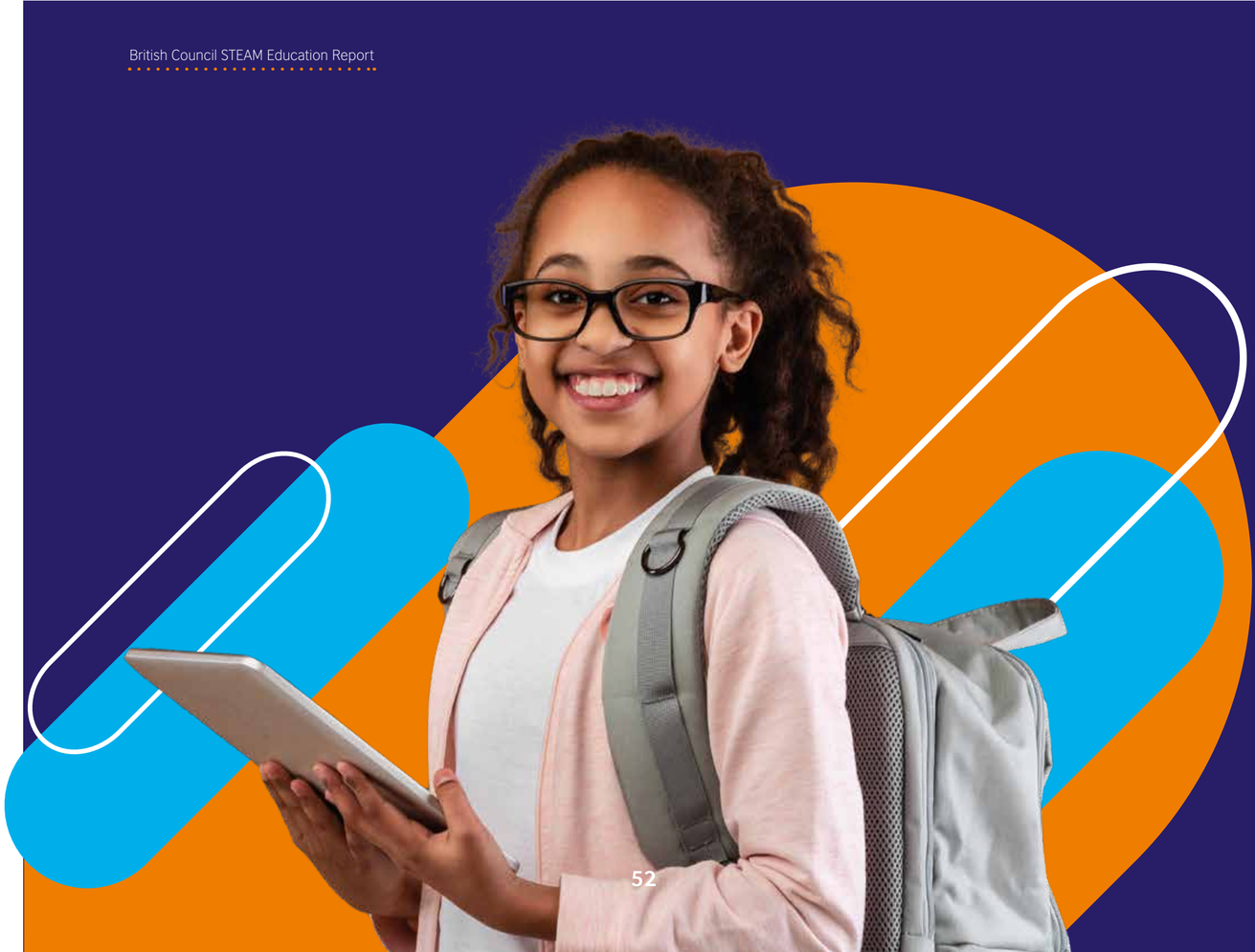
19. To provide funding and support for a popular science programme created for traditional and new media

20. To create a fund to support STEAM research

EXPECTED OUTCOMES AND IMPACT

The development and implementation of a national STEAM Education policy is expected to create an enabling environment to:

1. Shape and grow the National STEAM Ecosystem.
2. Establish and promulgate a national STEAM culture.
3. Embed STEAM Education at all levels of the Education landscape
4. Improve the quality of teaching in support of student learning.
5. Increase school completion rates.
6. Increase access, equity, and inclusiveness for Jamaicans in STEAM related fields.
7. Increase spending on research and development
8. Impact national GDP through greater involvement in STEM-related activities

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