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Current Challenges and Future Directions for STEM Education in the Caribbean

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Introduction

In their seminal *Caribbean Education Strategy Report*, Jules, Miller, and Armstrong (2000) argued that in order to meet the developmental objectives of an internationally competitive labour force by the year 2020, the Caribbean region would need to be able to demonstrate "a 30% increase in persons with qualifications in science and technology at the postsecondary level" (p. xviii). These authors also noted their concern that "the region as a whole lags far behind in science and technology, and a more concerted effort is needed to bridge that gulf" (p. 27). Responding to similar concerns, the Vice-Chancellor of The University of the West Indies indicated that by the year 2020, the institution should be training at least 50% of its students in science-technology-engineering- mathematics (STEM) and STEM-related disciplines to meet science and technology infrastructure needs in the Caribbean (Jaipaul-O'Garro, 2016).

As we rapidly approach the third decade of the 21st century, many Caribbean countries are now in the process of reforming their systems of public education. In particular, heightened emphasis is being given to STEM education and the enhancement of STEM literacy at all educational levels. In common with the Caribbean, various challenges regarding STEM education are being noted in other parts of the world (DeCoito, Steele, & Goodnough, 2016; Lee, Chai, & Hong, 2019). Such challenges include, for example, the current lack of consensus regarding definitions of STEM and STEM education research (English, 2016; Kelley & Knowles, 2016; McDonald, 2016; Nadelson & Seifert, 2017; Holmlund, Lesseig, & Slavit, 2018); systemic difficulties associated with STEM teacher education and professional development (English, 2016; Margot & Kettler, 2019); and the multiplicity of perspectives vis-à-vis the broader goals of STEM education and their proposed correlation with global social and economic development (Kramer, Tallant, Goldberger, & Lund, 2015; Smith & Watson, 2019).

Teaching and research efforts in science; technology; engineering; and mathematics education, respectively, have maintained a relatively steady and coherent presence in the Caribbean from the early 1970s to the present day (e.g. Lancaster & King, 1977; Haggis, 1984; Prime, 1992; King, 1994; Petty, 1994; Sweeney, 2003; Adams & Radix, 2018; George, 2019). However, similar coherence does not yet exist in the region for teaching and research efforts in STEM education. Without a clearly articulated vision for STEM education, efforts to enhance STEM literacy will remain fragmented and in embryonic form within our regional context. Thus, at least two key questions may be asked at this stage: *What is*

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the emerging contemporary Caribbean vision of STEM education for the region?; and, if such a vision exists, *How is it characterised, defined, and operationalised?* It is within these frames of reference—and in an attempt to provide answers to these questions—that the rationale for this JEDIC special issue was conceived.

The articles comprising this special issue clearly reflect the multiple interpretations of STEM/STEM education that currently exist in the region. Additionally, the articles illustrate a range of conceptual and methodological approaches used to design and provide instruction in various STEM fields. While the conceptual frameworks; methodologies; findings; and recommendations of the various articles are all subject to legitimate critique, the articles all represent educationally significant efforts for the Caribbean region and should be assessed in light of the implications they raise (both explicitly and implicitly) for the ongoing development of STEM education practice and policy in the region.

In *Reconceptualizing and Infusing STEM in the Early Childhood Jamaican Classroom*, Miguel Ison, Zoyah Kinkead-Clark, and Camille Berry discuss the fundamental importance of implementing effective STEM education at the early childhood level. Given the critical role of early childhood education as the basis upon which all subsequent formal teaching and learning is based, it may be argued that STEM education at this developmental stage deserves the keenest level of attention from education researchers, practitioners, and policymakers. In recent times, the STEM acronym has been expanded to include other subject areas such as Art(s)—STEAM education (e.g. Taylor, 2016) and Reading—STREAM education (e.g. Debroy, 2017). In a notable rejoinder to the current debate regarding the benefits of these additions, Ison et al. argue that if *fully* integrated conceptualisation and implementation of STEM education truly occurs, then such additions become inconsequential. If such an argument is accepted as valid, this suggests that radical changes are needed in the professional preparation of early childhood educators not only in the Caribbean, but worldwide.

In their article, *An Exploratory Study of Game-Based Approaches in Primary Mathematics and Science Classrooms in Trinidad and Tobago*, Rowena Kalloo and colleagues contend that while textbook-driven learning is insufficient for developing STEM skills for 21st century learning, game-based approaches have the potential to create contextual and authentic STEM learning experiences, particularly for students at the primary school level. In light of increased attention worldwide now being given to the positive learning outcomes associated with game-based learning (both digital and non-digital), the further development of culturally relevant game-based STEM teaching and learning approaches may hold considerable promise for the Caribbean.

Julian Thomas and Sharon Bramwell-Lalor address The Relationship Between Grade 9 Students' Attitudes Toward STEM and Their Achievement in Integrated Science. While the authors concede that "attitude" is a difficult construct to define in operational terms, they also adopt the stance that understandingthe affective dimensions of STEM learning is just as important as understanding its cognitive counterparts. Thomas and Bramwell-Lalor conclude their study by offering several important recommendations to increase students' interest, attitudes, and learning outcomes in STEM fields, with particular attention being given to mathematics.

A timely analysis is given by Kamilah Hylton, Kadia Hylton-Fraser and Natalie Guthrie-Dixon in *Evaluation of the Performance of STEM Academies in Jamaica: Using Data to Inform Decision-making*. At time of writing, STEM academies have existed for the past 4-5 years in Jamaica: however, as far as we are aware, there have not been any previously published evaluations of these academies. Following a comprehensive and constructively critical review of Jamaica's efforts to revamp and modernise its education system, the authors present a rigorous statistical examination of academic performance in Jamaica's recently established STEM academies. Their findings, analyses, and recommendations speak to the critical need for education systems in the Caribbean to use empirical data as the basis for far-reaching educational policy decisions. The continued growth of integrated STEM education in Jamaica will depend heavily on analyses such as this, as will the development of STEM education strategies and policies for the Caribbean region as a whole.

André Coy and colleagues present *A Review of a Tertiary Level Institution's Initiative for Enhancing Education in STEM at the Secondary School Level*. In addition to their informative commentary on Caribbean STEM education policies and initiatives, the authors also point out several barriers to STEM integration in the Caribbean, including inadequacies in education and training of both teachers and students at all educational levels. The efforts described by the authors highlight the characteristics of successful partnerships between universities and secondary schools, and emphasise the importance of tertiary level expertise in teaching and research being used to contribute to the development of STEM education goals at the pre-university level. The authors also note the multiple benefits of such an approach, which include "generating wider interest in STEM among high school students, recruiting undergraduates in STEM, producing more graduates in STEM, and ultimately increasing the love of science in society".

In *Realistic Mathematics Education (RME) Approach: Exploring Solving Differential Equations in the Learning of Calculus at the University of the West Indies, Mona*, Camella Buddo, Delmar Sherriffe and Avalloy McCarthy-Curvin present findings from their design–action research study. Beginning with their proposition that calculus is a branch of mathematics that is applied in all four disciplines of STEM, the authors proceed to discuss the conceptual connection between the Realistic Mathematics Education (RME) approach and the goals of integrated STEM education. Using examples from their study, they argue that students' higher-level thinking skills can be developed using the RME approach in contexts relevant to science, technology, and engineering, all underpinned by mathematics. Given the challenges that have been recognised regarding many students' negative attitudes to mathematics (noted by Thomas and Bramwell-Lalor in this special issue, and by other STEM education researchers elsewhere), the RME approach may well hold promise for addressing this widespread concern within the context of integrated STEM teaching and learning.

In the Caribbean, the Caribbean Examinations Council (CXC) serves as the premier assessment and certification provider. Almost all secondary and postsecondary institutions in the region rely on its independent endorsements of academic achievement (e.g. the Caribbean Secondary Examination Certificate [CSEC]; the Caribbean Advanced Proficiency Examination [CAPE]; and the CXC Associate Degree [CXC-AD], among others) to evaluate the academic and vocational preparedness of students at the pre-university level. In their contribution, *STEM Integration Initiatives of the Caribbean Examinations Council*, Alsian Brown- Perry and Linda Stewart-Doman comprehensively discuss long- term efforts by the CXC to incorporate STEM concepts and competencies into its extensive suite of examination products. As part of its goal to enhance and promote STEM literacy in the region, the authors highlight the school-based assessment (SBA) component of CXC examinations as being "the perfect conduit for the inclusion of STEM principles in the teaching, learning, and assessment process". Particularly noteworthy is the authors' discussion of "cutting-edge" CXC syllabi (e.g. CAPE Green Engineering; and CAPE Agricultural Science) which deliberately incorporate concepts of ecological sustainability and food security, respectively. The development of knowledge and competencies in areas such as these align well with the goal of improving overall STEM literacy throughout the Caribbean region.

The final article, *Creating a STEM-based Economic Pillar for the Caribbean: A Blueprint*, is written by Cardinal Warde and Dinah Sah. In their highly trenchant and informative commentary, the authors provide a "big picture" perspective that effectively contextualises this entire special issue. In essence, the authors ask (and respond in detail to) the following question: How can we design carefully crafted, regionally endorsed strategies and policies for STEM education that contribute to a more STEM-literate, economically viable, socially productive and innovative Caribbean region? Among the comprehensive recommendations provided by the authors are a technology company creation model; insights for supporting and sustaining new private sector company growth; development of a small business innovative research and development programme; and advice for establishing a shared regional research laboratory. The issue of workforce preparation in STEM fields is of critical importance to the Caribbean (e.g. Dixon & Hutton, 2016; Morris, 2017), which further heightens the urgency of seriously considering and adopting the recommendations provided here.

Concluding Comments and Future Directions

While acknowledging the valuable contributions made by these authors, we also recognise that the articles in this special issue represent only a *very* limited focus on the English-speaking Caribbean (and even so, not very broadly within this part of the Caribbean). What about the other parts of the Caribbean region that include the Dutch-speaking; French-speaking; and Spanish-speaking islands? In terms of developing their respective capacities in STEM education, what issues and challenges do they share in common with the English-speaking islands? Do these islands experience issues and challenges that are qualitatively and distinctly different?

Although not addressed explicitly by most of the articles featured in this special issue, we will use this forum to briefly outline four major considerations for the broader Caribbean at this time that will feature prominently in any regional effort toward integrated STEM education policy and practice. These considerations certainly are not exhaustive, but in our view, are of some importance within the historical and current social, political, and economic contexts of the region.

Returning to the issue of language, we note that "the Caribbean" is not a linguistically homogeneous community, and ostensibly is composed of Dutch-speaking; English-speaking; French-speaking; and Spanish-speaking islands, respectively. This is further compounded by the fact that although Dutch, English, French and Spanish might be the official languages of these countries, in practice, citizens of most, if not all of these islands regularly communicate in a variety of African-influenced creoles, patois, and dialects. This is an issue that will demand closer attention as our efforts to improve the quality of STEM education in the Caribbean gain momentum. The goal of understanding the specific terminology of specialised STEM content will need to be carefully balanced with how we promote literacy in STEM teaching and learning, and associated STEM curriculum development (Charity Hudley & Mallinson, 2017; Lodge, 2017; 2019).

As noted by Lee, Chai, and Hong (2019), "if it is already challenging for a teacher to master the pedagogical content knowledge (PCK) for a single subject, it would be even more difficult for him or her to develop PCK for interdisciplinary STEM learning" (pp. 1–2). Given the rather insular and territorial manner in which most of our academic units at the tertiary level currently operate, this might be one of the most daunting challenges to be faced at this level for STEM teacher education. The process of integrated STEM teacher education will require the professional preparation of teachers who are competent not only in one area of specialisation (as currently is the case), but in at least two or more STEM areas, along with the necessary pedagogical content knowledge to guide integrated STEM teaching and learning (Pringle, Dawson, & Ritzhaupt, 2015; Wu & Anderson, 2015; Uzzo, Graves, Shay, Harford, & Thompson, 2018). This will necessitate a major change in how STEM teacher education and subsequent professional development are conceptualised and undertaken at our regional institutions of higher education.

In addition to the concerns relating to the professional preparation and ongoing professional development of STEM teachers in the Caribbean, retention of such persons in the region's public education systems may prove to be challenging. Lewis (2011), for example, notes that, "[s]mall states of the Caribbean Community have the dubious distinction of being among the highest contributors of skilled nationals to developed countries" (p. 67). A recent report (Wilson-Harris, 2019) indicates that Jamaican science teachers are being actively recruited to teach in countries such as the United Kingdom, and such targeted recruitment of science and mathematics teachers from other Caribbean countries is not uncommon. It may be anticipated that future STEM teachers in the Caribbean region will be viewed even more so as valuable commodities to be recruited by (or even exported to) other countries. There will be a need to develop relevant education policies (as individual nation- states and as a region), that address both the retention and "managed migration" of STEM/STEM education professionals and associated social and economic factors of regional importance (Lewis, 2011; Brissett, 2019).

Finally, in looking to the future, those involved in STEM research and STEM education in the Caribbean will need to consider the extent to which the region productively engages with a variety of 21st century STEM issues, topics, and concepts. These include, but are not limited to, various biotechnologies used in genetic engineering; the ongoing development of nanomedicine (Sweeney, 2015); the increasing use of nanotechnologies and nanomaterials in a wide variety of industries; nanoscale science and engineering education (Sweeney & Seal, 2008); artificial intelligence (AI) research and the progressively sophisticated development of "social robots"; and the rapid growth of the "Internet of Things", leading to the emergence of "smart cities" (Sweeney, 2019a). By taking STEM education "to the next level", the Caribbean region will be in a stronger position to determine for itself the implications that currently emerging and convergent technologies will have for its future development (Sweeney, 2019b).

In conclusion, we especially wish to thank the authors of articles appearing in this JEDIC special issue. These articles serve as the first repository of scholarship specific to STEM education in the Caribbean, and our intent is that this body of work will stimulate and guide further STEM education initiatives throughout the region. In so doing, our ultimate goal is to begin the process of developing integrated and effective STEM education policies for our region.

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We trust that you will find this special issue to be inspiring and professionally useful as we continue in our joint efforts to advance STEM education in the Caribbean.

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