POSITION STATEMENTS ON INTRODUCTION OF SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) EDUCATION IN GHANA

1. Introduction

The Art Teachers' Association of Ghana (ATAG), a registered professional body at the forefront of Arts education delivery in Ghana, with membership comprising of seasoned Art Educators at both pre-tertiary and tertiary levels of education in Ghana, in collaboration with the School of Creative Arts (SCA), University of Education, Winneba present their official position on the recent adoption and implementation of STEM (Science, Mathematics and Technology) educational policy by the Ministry of Education and the National Teaching Council.

The National Teaching Council in collaboration with the Ministry of Education organised stakeholders meeting on August 10, 2021 in Accra on the theme *'STEM Education in Ghana: What Ought to Happen'*. We observed that the eminent scholars invited for the presentation on the said date were drawn from science, engineering and mathematics background just as the theme suggested. The incisive presentations from these scholars hammered on the aforementioned subject areas – Science, Technology, Engineering and Mathematics – as key in training the twenty-first century learner in Ghana.

However, drawing cue from best practices of advanced and developing nations who are making giant strides in inventions and innovations points to the fact that those countries have prioritized certain fields of study we (in Ghana and some parts of Africa) have neglected in addition to Science, Technology and Mathematics. Based on best global practices, ATAG and SCA make its position clear on the continuous exclusion of Arts Education in the promotion of Science, Mathematics and Technology (STEM) education policy in Ghanaian educational policies.

2. Brief Historical Background of STEM Education in Ghana

Since the country attained independence in 1957 there have been efforts by different governments to promote Science and Mathematics education. At the beginning of the country's formal school education system, it prioritized Science and Mathematics and later included Technology. The nation's concentration, therefore, dwelled on Science, Technology and Mathematics which became known as STM. For over four decades of attempts at promoting the aforementioned fields of study in Ghana, the nation has not made any creative and innovative contributions to global basket of Science and Technology inventions. The resolve of the Ministry of Education to introduce STEM (Science, Technology, Engineering and Mathematics) education is laudable. However, exclusion of the 'Arts' in the said policy has serious implications and consequences on the success rate and holistic development of creative and inventive learners.

3. STEM Education in Ghana and Recommended Policy Alternative

In the continuous quest to accelerating national development, the educational systems of both developed and developing nations have over the years witnessed policy alternatives. In the case of Ghana, past and present governments have initiated many major policies to finetune the educational sector for the holistic development of learners. One of such educational policies which has become a core component of the Ghanaian education system is Science, Mathematics, and Technology Education (acronymised as STEM). The philosophy behind STEM policy is based upon the idea that the study of Science, Technology, Engineering and Mathematics in schools could produce the best and innovative brains to act as scientists, engineers and architects to drive national development. This notion of STEM education being the sole magic wand to producing capable workforce to drive the desired national development has made Ghana governments (past & present) and their supporting ministries and agencies to continually allocate more resources for the advancement of STEM education in the country. Based on the historical trajectory and observation of the workable happenings in advanced countries, the position of the Art Teachers' Association of Ghana and School of Creative Arts of the University of Education, Winneba on the exclusion of the Arts is as follows:

1. Advanced countries such as China, USA, UK, France, Malaysia and Singapore have rigorously shifted from STEM (Science, Technology, Engineering and Mathematics) to STEAM (Science, Technology, Engineering, Arts and Mathematics) and or STREAM curriculum because ***they acknowledged that the pursuance of science, technology, engineering and mathematics education are enablers since the resultant must be a product, which is mostly physical manifestation of artificial intelligence.*** For this reason, ***they do not downplay the Arts***, which has to do with product design and development. STREAM suggest inclusion of 'Robotics' to 'Science, Technology, Engineering, Arts and Mathematics' (Marshall, 2004; Lunn & Noble, 2008; Colucci-Gray, Burnard, Cooke, Davies, Gray & Trowsdale, 2017; Harris & de Bruin, 2018; Skorton & Bear, 2018 as cited in Braund & Reiss, 2019). Many experts in Mathematics, Engineering and Science testify that the arts have the ability to draw curiosity, helpful in observation and accurate self-expression, perceive an object differently, express emotions and construct meaning personally, encourage team or independent work (Sousa & Pilecki, 2013).

   The general observation is that the STEM education system is not producing the much-expected STEM-capable graduates let alone producing graduates with 21st century competencies outside STEM curriculum to address the changing developmental needs of economies across the world. As a result of this inherent weakness of STEM, "the original motivators for STEM are even missing in the curricula cropping-up everywhere" (Catterall, 2017, p.5). It is so because, no country has ever developed in the absence of effective Creative Arts education, for Science and Technology thrives in the presence of art education (Essel, Navei, Quarshie & Donkoh, 2020). The fact remains that STEM curriculum is not a magic bullet for innovation but rather, a focus on STEAM could be described as an opportunity for teachers [and learners] to collaborate, learn and teach about the areas where Art and STEM intersect (Harris, 2012

as cited in Williams, 2013). Application of this is evidenced in countries who consider a STEAM (Science, Technology, Engineering, Arts, Mathematics) curriculum instead of STEM.

2. Studies have revealed that for a true innovative education, the inclusion of the Arts may extend students' critical thinking skills and provide multiple lenses through which they explore the world around them (Atalay, 2011; Williams, 2013; Catterall, 2017; Adkins, Rock & Morris, 2017; Artwatch Ghana, 2017). It is based on the justifiable impact of Arts on students' learning that led to the modification of the STEM policy to STEAM and STREAM respectively with the 'A' in both instances representing the Arts and 'R', Robotics or Reading. The introduction of the 'Arts' into the prioritised disciplines demonstrates the dependency of the disciplines - Science, Technology, Engineering and Mathematics on Art "because no great products were ever created without artistic sensibilities" (Stephen, 2015, p.2). Due to this, the world's much talked about technologically advanced nations such as; China, United States of America, Singapore,

   Korea and others have adopted and promoted STEAM or STREAM curricular which is worthy of Ghana's emulation as they produce graduates with high degree of inventiveness, innovativeness and creativity. Catterall (2017, p.5) typified that the people of China are grasping all the expertise they could concerning STEAM education because they believe STEAM education has the tendency to "allow the labels of the future to say "invented in China" rather than "made in China." It's a cash cow, having your citizenry trained via STEAM. Catterall further explains that STEAM modes of learning make students more creative, innovative, inventive and more empathetic. The justification is that:

   > …when students are allowed to express their own individual creativity and what is really true for them through their work[s], they begin to identify with it[them]. The true magic of STEAM education is that it allows all students to identify with science, technology, engineering, and mathematics. It takes those subjects out of the deep dark closet of incomprehensible textbooks, role models with no resemblance to any role any kid would want to play, and in the worst and darkest part of that closet, feelings of deep inadequacy. (Catterall, 2017, p.5)

3. Also, many scientific advancements in the past were stimulated by interaction with the Arts as it is an uncontested fact that some of the world's renowned/first class scientists had Creative Arts background (Adkins, Rock & Morris, 2017). For instance; Leonardo da Vinci who was both a great Scientist and a renowned artist noted to have drawn the first realistic representations of human anatomy together with other masterful works of art has leanings to the interplay of his scientific and artistic orientation (Atalay 2011; Adkins, Rock & Morris, 2017). In addition, the astronomer, Galileo Galilei, used the aesthetic and observational training he received in a fine arts education to inform his discoveries in both fundamental and applied science (De Padova 2008 as cited in Atalay, 2011). In a similar vein, the chemist, Niels Bohr, is remembered best for his

4. realisation that electrons were not discreet entities orbiting the atomic nucleus like planets orbiting the sun, but rather were probabilistic in nature and unavoidably influenced by the way they were observed (Adkins, Rock & Morris, 2017). Bohr's cubic artistic background and ability to deconstruct human forms into abstractions led him to an intellectual leap that revolutionised the human's understanding of the physical world (Miller 1995; Miller 2012; as cited in Adkins, Rock & Morris, 2017).

5. In another breadth, if children could build scientific projects using motion and engineering that express something about them and their personal contexts, it means that such children have suddenly discovered their inner engineering attributes. And, if learners "can use the concept of fractions to choreograph a dance that shows something about how they feel inside, they will learn that math can be creative and exciting. STEAM can do that" (Catterall, 2017, p.6).

   With each of these aforementioned examples, artistic training favours science both through the stimulation of imagination and the cultivation of observational and technical skills (Adkins, Rock & Morris, 2017). This is due to the fact that children's artistic expressions are inborn and have the potency of directly influencing generality of their learning and other activities both in school and at home (Wachowiak, 1977; Amabile, 1983; Burrows & Wolf, 1983; Lowenfeld & Brittan, 1987; Mattil & Marzan, 1981; Gehlbach, 1991, Gordon, 1999; Koster, 2005). For emphasis, Melissa (2015, p.i) says that:

   > Every child is born with creative potential. It is our job in early learning programs and later school years to nurture that creativity and support resourceful problem-solving, imaginative thinking, and transference of skills and knowledge to new experiences. This new review adds to the growing evidence about how arts participation helps young children develop strong social and emotional skills. Yet we need to delve deeper into how and why the various art forms impact children's learning. And then most importantly we need to get this information into the hands of teachers who need more assurance that increasing the use of the arts can benefit children's learning in language and literacy, math and science, and most importantly in social-emotional development.

Melissa's viewpoint as expressed, re-echoes the numerous reasons that support STEAM or STREAM educational policy in place of STEM. For the sake of emphasis, "STEAM education empowers and immerses students and educators in inquiry, dialogue, problem solving, and experiential learning that deepens understanding of all fields in their educational experience" (Huser, Joyce et al. 2020). As a result of the contextualised connection between contents and application, students in arts- STEAM classrooms tend to outperform their counterparts in STEM-only establishments (Inoa et al., 2014, as cited in Huser, Joyce et al. 2020). This makes the STEAM the recommended pathway for the holistic education of the Ghanaian learner.

3. Conclusions

In the quest for a robust educational policy that would produce the best and innovative brains to act as scientists, engineers, product designers and architects to drive the development of Ghana, the Art Teachers' Association of Ghana and the School of Creative Arts, University of Education, Winneba calls for a paradigm shift from the current focus on Science, Technology, Engineering and Mathematics (STEM) policy to either Science, Technology, Engineering, Arts and Mathematics (STEAM) or Science, Technology, Robotics / Reading, Engineering, Arts and Mathematics (STREAM) policy for the entire pre-tertiary and tertiary school levels to engender creative, innovative and inventive talents in learners for accelerated national development. STEAM education is known to foster pure innovation that comes with team work and critical thinking skills of scientist or technologist with that of an artist or designer. It enhances interdisciplinary learning for better results. With STEAM or STREAM education, students are presented with a more authentic vision of science in Arts and the Arts in science. Therefore, it is the position of ATAG and SCA that the education ministry would reconsider its long pursuit of STM and now STEM policy in Ghanaian educational curriculum and urgently prioritise STEAM that incorporates Arts Education as the robust vehicle that could realistically and forcefully drive creativity and innovation in learners.

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