Published by International Multidisciplinary Journal of Research and Education (IMJRE)
Vol. 01, No. 01 (2023), ISSN: 2961-0079 (Online), 2961-0060(Print).

INVESTIGATING THE CHALLENGES TO SUCCESSFUL IMPLEMENTATION OF STEM INTEGRATION EDUCATION IN GHANA

John Takyi-Bondzie, Samuel Kwesi Asiedu-Addo & Jemima Saah
Department of Mathematics Education, University of Education, Winneba, Ghana

Abstract

The purpose of the study was to look at the major challenges that need to be addressed as Ghana toes the path of STEM integration education. The study used concurrent mixed method as the study design and purposive and snowball sampling to sample thirteen (13) stakeholders. The stakeholders were teachers, parents, administrators for private STEM organizations including government officials in charge of STEM education in Ghana and a representative from Ashesi Design Lab. The instruments used for the data collection were questionnaire items for the quantitative part and a semi-structured interview for the qualitative part. All thirteen respondents answered the questionnaire whereas 12 respondents availed themselves for the interview. The data gathered were analysed separately yet concurrently. The quantitative part was analysed using percentages with the aid SPSS 24.0 software and the qualitative data were analysed using coding and themes. The findings reveal that a lot of teachers lack deep knowledge about STEM contents and pedagogical knowledge about how to integrate them, etc. The study recommends that the government of Ghana, through GES, must ensure that there would be training and retraining of teachers to be abreast with the acronym STEM and STEM integration education.

Keywords: STEM integration, STEM education, challenges, successful implementation of STEM education

Introduction

Employers today are looking for employees who can multitask (Doyle, 2021). In the wake of this, producing a Science, Technology, Engineering and Mathematics (STEM) literate citizenry and skilled workforce today is the focus of governments across the globe (Gough, 2015). STEM education is an interdisciplinary approach to learning where serious academic concepts are combined with real world lessons as students apply science, technology, engineering, and mathematics in a way that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, 2009). STEM education offers students one of the best opportunities to make sense of the world holistically, rather than in bits and pieces (Tsupros, 2009; Andrews, 2015).

The provision of scientific and economic superiority of a nation depends on trained individuals in STEM education (Raines, 2012). This assertion corroborates the UN Sustainable Development Goals (SDGs) such as the Incheon Declaration for Education 2030. That declaration recommends the strengthening of STEM education as a key strategy for meeting its sustainable development goals (UNESCO, 2015). Unfortunately, research into STEM education is very low in Africa (World Bank, 2014). In accordance to the report African Government ministers agreed in March, 2014 on a Joint Call for Action to adopt a strategy that uses strategic

investments in science and technology to accelerate Africa toward a developed knowledge-based society within one generation (ibid). The African Union has strategies of inclusive growth, job creation; increasing agricultural production; investments in science, technology and innovation, including the development of human capital through sustained investments based on universal early childhood development and basic education as part of its future agenda. It is the expectation that these would make African nations, by 2063, rub shoulders with the other developing and developed nations (Agenda 2063).

It is heartwarming that the government of Ghana heeded to the need to pay attention to this wind of change in the educational system around the world. The government of Ghana has shown the interest to promote STEM integration education in this country. For example, the government of Ghana has introduced the Basic STEM (BSTEM) initiative. The BSTEM initiative is to create a pipeline of science, technology and technical oriented students with requisite skills and competencies to advance socio-economic development of the country (MOE, 2019). Again there are private STEM organisations including STEMBees, GHScientific, JA Africa, etc., who are promoting the STEM integration education agenda. This is good news because creation of new types of jobs and the broadening requirements of existing jobs in Ghana are identified as important issues for integration of STEM in education policies (Kane, 2011; MEST, 2010). Within the Ghana Education Strategic Plan 2010-2020, attention was paid to the demands for STME (Science, Technology and Mathematics Education) otherwise known as STEM in other parts of the world. The purpose of the STME policies was to strengthen the teaching and learning of science, technology and mathematics at all levels of the educational system so as to produce a critical mass of human resources that would stimulate Ghana's technological capacity (MOE ESPR, 2010). However, according Takyi-Bondzie, Asiedu-Addo, and Saah, (2022), the government STEM education agenda cannot be achieved lest it pays attention to factors including Supportive systems, Curriculum, Well qualified STEM teachers, Teachers' professional development, Infrastructure and Monetary resources.

Despite the potential benefits and the increased focus on STEM integration education, implementation of this new instructional strategy faces several challenges. These challenges include inadequate supply of trained STEM teachers, teachers lacking deep knowledge about STEM contents and pedagogical knowledge about how to integrate them, inadequate resources for teaching and learning in STEM related programs, inadequate funding, etc., (Adu-Agyeman and Osei-Poku, 2012, Mgbono, 2013, Takyi-Bondzie, Asiedu-Addo, and Saah, 2022). These aforementioned challenges, if not tackled head on, could thwart every effort that would be put in place in promoting STEM education in Ghana.

There is inadequate supply of STEM professionals in Ghana (MOE, 2014). In the Universities (both Technical and non-Technical), there are more students enrolled in arts and humanities subjects than in science-based subjects because there are fewer qualified science and mathematics candidates (See National Accreditation Board: Tertiary Education Statistics Report for 2015/2016). This goes contrary to the national policy of 60:40 Science/Humanities ratio approved by National Council for Tertiary Education (NCTE). To buttress, the (NCTE) report for 2012/2013 on student's enrollment into Ghana's eight public Universities indicated that 39 % out of 127, 502 students admitted were into Science related disciplines (Hassan, 2016). The effect is that there would be few teachers who would have expertise in Science, Mathematics and other STEM fields in our public pre-tertiary schools. Besides, the attrition rate of teachers, especially pre-tertiary teachers in Ghana, is too high. The Ghana Association of Teachers (GNAT) has

reported that, the attrition rate of pre-tertiary teachers from Ghana Education Service (GES) stands at approximately 7000 annually (Sottie, 2019). Another issue of concern is the efficacy of even the current teachers on the field teaching these disciplines. Stohlmann et al., (2012,), postulate that some teachers already have holes in their knowledge of the subject area. Therefore, asking them to teach a concept outside their area of specialisation would pose a lot of challenge for them. Students' learning is limited when teachers' knowledge and understanding is deficient (McMullin and Reeve, 2014). Therefore, teachers who have limited knowledge and discomfort with STEM contents may feel inadequate to teach it. Nevertheless, according to Takyi-Bondzie, Asiedu-Addo, and Saah, (2022), if teachers are well trained in STEM integrated education, with or without a lot of resources they can still give a good STEM education. Therefore, there is a need to priorities the training of teachers.

According to Education Strategic Plan 2018-2030 Ghana, Ministry of Education, 2019, "Ghana has devoted substantial resources to the education sector in recent years and has exceeded associated international benchmarks when including internally generated funds, outperforming all other West African countries". This is laudable, however, there is more room for improvement. According to the African Education Watch, known for short as Eduwatch, there are currently over 5,000 schools under trees and 4,500 primary schools without Junior High School (JHS) (Eduwatch, 2021). Moreover, a study conducted by Adu-Gyamfi (2014) on the challenges faced by science teachers in the teaching of integrated science in the JHS in Ghanaian schools, revealed that most schools lack laboratory facilities and logistics. This makes the teaching of science difficult for the students.

Furthermore, the cost involved in STEM education is quite huge. Provision of STEM learning resources such as construction tools (e.g., saws, measuring devices, and hammers), electronic materials (e.g., computers, design programs, robotics kits, and calculators) and other materials used in design (e.g., wood, Styrofoam, glue, cardboard, or construction paper), laboratories (Stohlmann et al., 2012, Nadelson and Seifert, 2017, Adu-Gyamfi, 2014) all requires a lot of funding. According to Eduwatch, (2021), government must priorities spending on education. According to them, a colossal amount of GHc34.8 million was spent on purchasing a set of pasts questions for WASSCE candidates in 2021. That money could have been used to tackle some of the myriads of problem confronting the educational system in Ghana.

Methodology

The study employed concurrent triangulation design, which is a mixed method approach in which data collection is only one phase during which quantitative and qualitative data are collected and analysed separately yet concurrently. Purposive and snowball were the sampling techniques used to select participants for the study. The participants included teachers, parents, administrators/representatives, as well as governments officials. The sample size for the study was thirteen (13). Table A gives the summary of how the sample size was constituted.

Table A: **Summary of sample size**

Sample	**Number**
A STEM hub representative	1
A STEM facilitator/administrator for a private STEM organization	4
Government official in charge of STEM Education	2
Teacher	3
Parent	2
A Representative of Ashesi Design Lab	1
Total	**13**

As presented on the Table A, the first participant is the STEM Hub representative in Accra Central Library. This if followed by four STEM facilitators/administrators from STEMBees, GHScientific, JA Africa and AU-NEPAD. Then we have two government of Ghana officials in charge of STEM education in Ghana. Followed on the list are three teachers: who are an integrated science teacher at Kaneshie Secondary Technical School, a STEM educator from STEMBees and an Education Statistics teacher from the University of Education, Winneba. The list continues with two (2) parents with one (1) from Nsaba Senior High, Agona Nsaba, whilst the other parent was from Nyarkrom Senior Technical High, and Agona Nyakrom, and lastly, a representative from the Ashesi Design Lab of the Ashesi University.

The Table B below provides the summary of participants' responses. The responses are quantified in percentages. In this study, five (5) items were considered as being the major challenges to successful STEM integration education in Ghana

These were: inadequate supply of trained STEM teachers (1), inadequate resources for teaching and learning in STEM related programs (2), Teacher's lack deep knowledge about STEM content and pedagogical knowledge about how to integrate them (3), It is costly to implement STEM education (4) and there is lack of consensus about what STEM integration education should be (5).

Table B: Major challenges to successful STEM integration education in Ghana

Statement	Strongly Agree and Agree	Neutral	Strongly Disagree and Disagree	Total
There is inadequate supply of trained STEM teachers	10 (76.9)	2 (15.4)	1 (7.7)	13 (100)
There is inadequate resources for teaching and learning in STEM related programs	11 (84.6)	0 (0)	2 (15.4)	13 (100)
Teacher's lack deep knowledge about STEM content and pedagogical knowledge about how to integrate them	11 (84.6)	0 (0)	2 (15.4)	13 (100)
It is costly to implement STEM education	9 (69.2)	2 (15.4)	2 (15.4)	13 (100)
There is lack of consensus about what STEM integration education should be	6 (46.2)	3 (23.1)	4 (30.8)	13 (100)

Source: fieldwork 2020

It could be seen form Table B above that the supply of trained STEM teachers was the first challenge raised in this study. The respondents showed their level of agreement that inadequate Trained STEM teachers or instructors is a challenge to successful STEM integration education in Ghana. Of the thirteen respondents, 76.9% saw inadequate supply of trained STEM teachers as a challenge whilst 15.4% were neutral and 7.7% disagreed to the assertion. The issue of inadequate resources for teaching and learning in STEM-related lessons as raised by this study saw 84.6% of the respondents agreeing to it as a challenge while 15.4% disagreed. On the issue of Teachers lacking deep knowledge on STEM and the pedagogical knowledge about how to integrate it, 84.6% of the respondents of this study saw it as a great challenge that needed to be looked at critically while 15.4% disagreed. That is very crucial to integrating STEM education in this country. The issue of cost too poses a challenge to integrating STEM education in this country. This study found out that 69.2% of the respondents agreed that it would be costly to implement STEM education in this country, even though 15.4% were neutral to the assertion whereas 15.4% disagreed. The last challenge identified was that of the absence of consensus as to what form STEM integration should take. Of the thirteen respondents, 46.2% agreed that the lack of consensus was a challenge to successfully integrating STEM education, 23.1% remained neutral on the issue and 30.8% disagreed.

In line with the design for the study, twelve (12) of the thirteen (13) of the respondents were interviewed for further explanations. When it comes to the knowledge about STEM integration contents and how to blend or integrate them, a respondent was of the view that:

> *"Our knowledge about STEM fields is not very widespread. Very few people understand STEM education today, so is a challenge. You talk about STEM education; everybody is talking about general education".*

This study had already established that in the contemporary education system, the nature of STEM integration education is a deviation from general education where STEM subjects are siloed or taught individually. Instead, STEM education is an integration of the two, three or more of the STEM disciplines

in a given lesson at a go in a way that makes connections between school, community, work, and the global enterprise. Commenting on the nature of STEM integration education, a respondent described his experience from a workshop he attended as:

> "*the process of developing a project, the idea of developing a project, writing up the project and making sure that project is executed. Based on what the child's ideas are, and how it has been explored based on the instruction given to the child, and then the facilitator assists the child to build up his project and come out with the project. Also included is the communication aspect, how a teacher would be able to communicate using the STEM education to let learners understand the concept of STEM*.

This would not be easy or straightforward especially looking at the current state of most of our teachers. To buttress, one STEM educator shared his experience by saying:

> "*it's not easy or it is not as straight forward as you know standing in front of the class and just you being the centre of attention and leading everything. This is because it is what you are trying to create an experience for the students. But you want them to explore and feel free and hopefully learn in the process at the same time, you try to put in very subtle guides and frameworks to ensure that their learning takes them in a certain direction. And that is not very easy to do. It requires a lot of preparations, it requires a lot of creativity, it requires problem solving, critical thinking, it requires all of this on the part of the teacher or the facilitator*".

To be able guide students to work with their hands, minds and hearts to come out with an output will require great skills. Currently, how many educators at the pre-tertiary in Ghana would be able to that? This shows that there is inadequate supply of trained STEM teachers. In view of the above comments, it would require that a lot of training and retraining be given to the teachers. Admittedly, a respondent said:

> *"there is need for reorientation of the teachers".*

On the issue of funding or cost as a challenge, all 12 participants interviewed agreed that funding is needed to create STEM integration awareness, run STEM workshops, buy and provide STEM integration logistics, etc. Commenting on this, respondents lamented by saying that:

> *"huge sums of money go into education but very little go into promoting STEM education".*

We cannot say that there has not been the allocation of funds to education at all in this country. In fact, the government of Ghana is doing well when it comes to general education. However, there are still schools under trees to suggest that we have a long way to go. So far, the success chalked by Ghana in STEM integration education are through some of the private STEM organisations. In spite of this, there is no allocation of funds for them. When asked about how they finance their programs, a respondent was of the view that:

> *"we try and source for funding from private individuals, academic societies, international organisations, to be able to finance the work that we do. So, whether is running training workshops, or hosting public engagements events, or even carrying out research projects we try and get funding from multiple sources to be able to do that"*.

No mention of the government, in spite of the fact that the government of Ghana has keen interest in the promotion of the STEM integration agenda in Ghana. If the government is serious about STEM integration

education, there is a need to set up a special fund or a budgetary allocation for the promotion of STEM education. For example, the money spent on the purchase of past questions for the WASSCE candidates in 2021 could have been channeled into the promotion of STEM integration education agenda.

Another thorny issue that popped up as a challenge was the issue of taxation on imported STEM kits or items. As already stated, all success involving STEM integration education so far can be attributed to some of the private STEM organisation such as STEMBees. However, for STEM kits or materials that these organisations import, they pay stipulated taxes on them. Lamenting, this is what one of them said:

> "In *view of the fact that STEM education is a new concept in this country, some or most of this/these material(s) are not available locally, and in view of this, requires importation which6 attracts import duties or taxes"*

This put extra financial burden on especially the private STEM organisations. If the STEM agenda will succeed, government ought to realize the need to scrap these taxes because these private STEM organisations are the pioneers in this endeavour. Therefore, giving them the needed support will help the government to succeed in this regard.

To undertake a research in STEM education is quite a daunting task due to its being new in the system, thus a lot of people do not know or understand what the acronym is all about. Research into STEM integration is very low. This is because as one of the respondents said:

> *"STEM involves a lot of resources, equipment's, etc., and so it is also a bit difficult for many people to spend time in going to develop STEM solutions*".

Inadequate cooperation from some parents whose children/wards volunteer to engage in STEM activities, heads of institutions, and some teachers poses a challenge. In an educational system that is exams focused, where the emphasis is on the final examinations, these are some of the reactions you are likely to meet. As a respondent put it:

> *"the pride of many schools today is the number of, and the amount of successes that are chalked in the final exams*".

In view of this, heads of some institutions are reluctant when it comes to cooperating for STEM activities because they think it will waste their students' time and hinder their academic progress. In addition, many parents whose children/ward are used on STEM projects are also discouraged because:

> *"they are made to feel that their wards are not learning or will be skipping lessons''*.

The situation is the same with some teachers too. According to some of the respondents for example:

> "*if they go to a school and explained to a teacher that they have a project that requires that they engaged with their student for say two hours a week over the next six months, where they would give them a problem, sort of like a problem-based learning scenario. The responses often have been "oh we have a problem and can't make the time"*.

It would be difficult to fault anyone in this regard. The problem is the pressure to let students pass the final examination. Thus, some teachers find it difficult to give maximum cooperation to STEM projects due to wanting my student to pass the exams syndrome, because the success of a teacher is based on the number

of students that passed the final exams and the teacher is willing to do that and just that. Aside that, some teachers see STEM activities as extra load on them and therefore are reluctant to budge for it.

In summary, the overarching challenges as outlined in Table B, as well as the responses from the interviews are: inadequate STEM professionals/ educators, knowledge of STEM content and how to integrate them not being widespread, inadequate resources for teaching and learning in STEM related field, funding/cost to create {awareness, to train the personnel, provide logistics, etc.}, inadequate research on STEM integration education were the main challenges. Added challenges were taxation and inadequate cooperation.

The challenge of inadequate supply of STEM professionals corroborates with the National Accreditation Board Statistics on Tertiary Education Statistics which reports that more students at both public and private Universities and even the Technical Universities are into the humanities than the sciences. This goes contrary to the national policy of 60:40 science/humanities ratio approved by National Council for Tertiary Education (NCTE with polytechnics Report for 2015/2016).

Again the challenge of inadequate resources for teaching and learning in STEM related field corroborates with Adu-Gyamfi (2014). According Adu-Gyamfi (2014), the challenges faced by science teachers in the teaching of integrated science in the Junior High Secondary School in Ghanaian schools are inadequate materials, lack of laboratory facilities, etc., which makes the teaching of science difficult for the students. The situation resonates with various schools.

Also, the challenge of teachers lacking deep knowledge of STEM contents and how to integrate them is supported in the literature. For example, Umoh, Akpan and Udongwo (2013), postulate that some teachers in our schools lack STEM content knowledge as well as the pedagogical skills to teach them effectively.

The challenge of inadequate research into STEM education corroborates the World Bank (2014) report that laments the under-research capacity on STEM education in Sub-Saharan Africa.

Integrated STEM education is very costly. Funding is needed to create STEM integration awareness, run STEM workshops, train personnel, carry out research, provide logistics, etc. This is concurred by Stohlmann et al., (2012) and Nadelson and Seifert, (2017) who are of the view that STEM education often requires a lot of money to provide the numerous materials and resources for students, teacher and awareness creation.

Summary and Recommendations

Effective STEM integration education is vital for the future success of students. In view of this it is vital that challenges including inadequate supply of STEM professionals, teachers lacking deep knowledge of STEM content and how to integrate them, etc., and other findings in this study need not to be overlooked. Therefore, the study recommends that the Ministry of Education (MOE) and Ghana Education Service (GES) must collaborate and provide schools with well-equipped laboratories together with other resources for effective teaching and learning to take place. Again, the government of Ghana through GES, must ensure that there would be training and retraining of teachers to be abreast with the acronym STEM and STEM integration education. They should also collaborate with the private STEM organisations draw up STEM

integration education programs that are workable for the Ghanaian students. The government must allocate funds for the development of this very important educational endeavour.

References

Adu-Agyeman, J & Osei-Poku, P. (2012). Quality education in Ghana: The way forward. International Journal of Innovative Research and Development. Vol 1 (9), ISSN 2278-0211

Adu-Gyamfi. K. (2014). Challenges faced by Science Teachers in the Teaching of Integrated Science in Ghanaian Junior High Schools. Journal of Science and Mathematics Education, 6(2), 59-80.

Agenda 2063 (2015). The African We Want. Final Edition, popular version: African Union Commission

Andrews, K. (2015). Jobs of the future: The known unknown. Australasian Science, 36(7), 38. World Economic Forum. (2016). The Human Capital Report 2016. Retrieved from https://www.weforum.org/reports/thehuman-capital-report-2016

Doyle, A. (2021). Important Multitasking Skills Employers Value. Updated August 18, 2021. Retrieved from http:// www.thebalancecarees.com .

Editorial StaffEDUCTION (EDUWATCH) (2021). There are 5,000 and 4,500 primary schools under trees and without JHS respectively-Eduwatch.

Ghana (2016). National Education Assessment Report of Findings. 2016 NEA Findings Report_17 Nov2016_Public FINAL.

Gough A (2015) STEM policy and science education: Scientistic curriculum and sociopolitical silences. Cultural Studies of Science Education 10(2): 445–458.

Hassan, F. (2016). Rethinking STEM education in Ghana. Retrieved from https://ghscientific.com/rethinking-teaching-stem ghanaian-schools/

Kane, Ch. (2011). 5 Reasons STEM Education will be the Key to Ghana's Success. At SocioLingo Africa. Retrieved from http://www.sociolingo.com/5-reasons-stem-educationwill-be-the-key-to-success-ghana

McMullin, K., & Reeve, E. (2014). Identifying perceptions that contribute to the development of successful project lead the way pre-engineering programs in Utah. Journal of Technology Education, 26(1), 22–46. https://doi.org/10.21061/jte.v26i1.a.2.

MEST (2010). Ministry of Environment, Science and Technology. National Science, Technology and Innovation policy. Accra, Ghana. Retrieved from http:// www.ecowrex.org/system/files/repository/2010_national-science-technology-andinnovation-policy_m.e.s.t.-ghana .pdf MOE ESPR (2010). Ministry of Education: Education sector Performance Report 2010. Accra, Ghana. http://ghmeforum.org/repository3/reportfiles/performance_report_2010.pdf

Mgbono, T. (2013): Empowerment of Science, Technology and Mathematics (STM) Teachers: A Strategy for the Realization of the Millennium Development Goals, Proceedings of the 54th Annual Conference of STAN, Pp. 69-73.

Ministry of Education (2014). INSPIRING SCIENCE AND MATHEMATICS IN BASIC SCHOOLS Report of the committee that reviewed basic science and mathematics education in Ghana Republic.

Ministry of Education (2019). Education Strategic Plan 2018-2030 Ghana, Ministry of Education. Retrieved from https://www.//ghanaweb.com/GhanaHomePage/

MOE ESPR (2010). Ministry of Education: Education sector Performance Report 2010. Accra, Ghana.

Nadelson, L. S. and Seifert, A. L. (2017). Integrated STEM defined: Context, challenges, and the future. *The Journal of Educational Research*, 110(3), 221-223. https://doi.org/10.1080/00220671.2017.1289775

Raines, J.M. (2012). FirstSTEP: A preliminary review of the effects of a summer bridge program on pre-college STEM majors. *Journal of STEM education, 13(1), 22-29.* Retrieved from www.wathi.org

Sottie, E.E. (2019). High attrition rate of teachers worrying-GNAT. Retrieved from www.graphic.com.gh>education

Stohlmann M., Moore, T. J & Roehrig, G. H. (2012). Considerations for Teaching Integrated STEM Education. *Journal of Pre-College Engineering Education Research, 2(1),* 28-34. doi: 10.5703/128828314653.

Takyi-Bondzie, J., Asiedu-Addo, S.K and Saah, J. (2022). Investigating Factors to be Considered for Successful STEM Integration Education in Ghana, International Journal of Mathematics and Statistics Studies, Vol.10, No.2, pp.40-51

Tsupros, N., R. Kohler, and J. Hallinen, 2009. STEM education: A project to identify the missing components, Intermediate Unit 1 and Carnegie Mellon, Pennsylvania.

Umoh, S. W., Akpan, A. E., Udongwo, A. M. (2013): Human Resource Development for Effective STEM Education: A Pre-requisite for Sustainable Development in Africa. Academic Discourse: An International Journalf Vol. 5 (1), pp. 195-201

UNESCO (2015) Incheon Declaration and SDGE - Education 2030 Framework for Action. Available at: http://unesdoc.unesco.org/images/0024/002456/245656Es.pdf (accessed 21 August 2017).

World bank (2014). A Decade of Development: Science, Technology, Engineering and Math (STEM) Research in Sub-Saharan Africa. World Bank-Report Nr 91016. Washington, DC. World Bank Group. Retrieved from worldbank.org/Africa/stemresearchreport.