An Inclusive Approach to Hands-on STEM Programs in Underserved Secondary Schools: An Epistemological STEAM Model

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***Abstract* - Underserved schools globally do not usually have sufficient resources and requisite models to run inclusive and sustainable hands-on STEM programs. This often lead to exclusion of more students from opportunities in STEM, especially those with disabilities and learning difficulties. The marginalization of disadvantaged learners and exclusion of majority of students in resource-poor schools creates an internal STEM gap. Some schools having resources but lacking skilled instructors also face the same challenges. After more than a decade of casual observations, these problems have remained consistent, persistent and widespread; especially in developing countries. This mixed and longitudinal study therefore proposes an inclusive framework to address these inequities in STEM. Our model comprises seven components, after inductive analysis of empirical observations. A survey of 214 participants comprising 36 teachers and 178 students, who have participated in hands-on STEM programs was analyzed using simple statistical method to evaluate their perceptions on our hypothesized propositions. Our findings reveal that teachers' and students' responses validate our proposed framework; which informs the development of our Epistemological STEAM Model. This framework would serve as an effective guide for underserved secondary schools to implement sustainable hands-on programs with limited resources. It would also help policy makers enforce inclusion in the selection of students who participate annually in sponsored STEM programs and competitions; as well as drive optimal utilization of public STEM infrastructures.**

Index Terms – Closing the gender digital divide, Epistemological model, Secondary schools, STEM to STEaM, Inclusion.

INTRODUCTION

The world today thrives on technological revolution powered by tech-skilled workforces. It is well established that the cumulative digital competencies and scientific index of any society depend heavily on the quality and strength of STEM(science technology engineering math) foundation and diversity of her workforce[1]. Hands-on and collaborative project-based learning enable students gain deeper understanding, problem-solving and critical thinking skills while preparing them for workplace driven by technology[2]. International agencies, governments and stakeholders around the world are investing heavily on inclusive stem interventions.

The concept of STEM was first introduced in the 1990s by the National Science Foundation. [3] describes STEM education as multidimensional and epistemologically constructivist, as learners can construct knowledge through discovery and problem solving. However in implementing any STEM curriculum, all four disciplines do not necessarily have to be incorporated every time[4] but rather give students the opportunities to learn and apply knowledge and skills gained. Teaching hands-on STEM in underserved high/secondary schools within Africa and globally is daunting due to numerous challenges. Some of these persistent difficulties include lack of STEM resources, insufficient skilled teachers or instructors[5], insufficient time for learners to grasp concepts especially when instructors are external, exclusion of girls and students with learning difficulties/disabilities, amongst others. What is even more worrisome is the internal gap created between students' groups during implementation of STEM programs, leaving some students completely marginalized even in underserved schools. For example, a school with limited resources may be invited to nominate few students to attend a sponsored STEM bootcamp or competition preceded by intensive hands-on STEM training. Some schools usually would select the perceived brilliant students or fast learners for such programs, or even go as far as inequitably selecting the same set of students for all openings yearly, further widening the internal STEM divide. Hence same set of students, selected by teachers or school administrators to attend STEM programs, could receive up to 12 different trainings within their 6 years in high school, while other students would receive non. This is not done intentionally as the schools would rather put their best forward to increase their chances of winning.

Having identified these barriers to teaching hands-on STEM, several studies have suggested solutions to these challenges. However, to the best of our knowledge, there exists no empirical study investigating an inclusive approach to hands-on STEM programs in underserved high schools with a recommendation of evidence-based STEAM (STEM and Arts) model.

The purpose of this mixed study is to create a simple conceptual framework and epistemological STEAM model to guide underserved high schools to successfully implement inclusive STEM projects and to strengthen public policies in the enforcement of inclusion in STEM programs.

The following questions(Q) guide this study:
Q1:How can underserved secondary schools implement sustainable hands-on programs with limited resources?

Q2:To what extent would an evidence-based STEaM framework boost inclusive participation in STEM programs by underserved schools?

Q3: How can underserved schools bridge the aesthetic communication gap in STEM amongst students?

BACKGROUND

The Federal Ministry of Communications and Digital Economy(FMoCDE), formerly Ministry of Communications Technology(COMMTECH), launched the Digital Girls Club (DGC) in 2014 [6], first in 12 schools [7], [8] and has now grown to hundreds of schools across the country. Women in Technology in Nigeria (WITIN) and Women's Technology Empowerment Centre (W.TEC) developed the initial contents and curriculum for the DGC portal. The contents included hands-on tutorials and projects on games using Alice, Programming, Graphics, Coding with Python, HTML, JavaScript; Computer Hardware, Websites and Mobile Apps Development; Internet Safety, amongst others. The project is implemented by the Planning Research and Statistics (PRS) department of FMoCDE and currently managed by WITIN[9]. Other modules later added included UI/UX Design, Machine Learning, Artificial Intelligence, Computational Thinking amongst others. The aim of setting up the DGC was to close the digital gender gap by encouraging more girls in Nigeria to pick and retain careers in STEM. The DGC runs annual hands-on STEM competitions preceded by intensive bootcamp. Usually, the call for participation is published widely both in national dailies and social media to enable schools indicate interest, afterwards, some schools are screened for participation. Girls from secondary schools across the country's six geopolitical zones are selected and trained for several days accompanied with fun activities, before they compete. All participants go home with exciting gifts while the winners are rewarded with cash prizes[10] .

The Nigeria Communications Communication(NCC), also a parastatal of the FMoCDE launched its maiden Nigeria Girls Can Code (NGCC) Competition in 2022. The aim for the NGCC is similar to that of the DGC[11], [12], however it focuses more on digital skills in alignment with the National Digital Economy Policy and Strategy (NDEPS) 2020-2030. The first call for NGCC entailed 54 schools who indicated interest across the six geopolitical zones. Twelve schools were selected from each zone of the country and were trained for three weeks on how to use C/C++ to program microcontroller boards (Arduino nano), connecting sensors and actuators (eg motion sensor, ultrasonic sensor, servo motors etc), sending data to the cloud with IoT capability boards(Esp32) using 5g network, and monitoring the data via mobile or desktop platform (eg, Thingspeak, Blynk etc). Each school(11 of the 12) represented by 3 girls and accompanied by their teachers were invited to Abuja for a 3 day-bootcamp and contest. On the 1st of February 2023 [12], all participants attended the prize giving and award ceremony. Girls went home with exciting gifts while the winners were rewarded with cash prizes. WITIN's Alade also participated as a judge in the NGCC contest[13] and the NCC's ICT Innovation Competitions for 2022 and 2023[14], [15], [16], [17].

WITIN also runs internal projects on digital skills and literacy for girls starting from 2002 when WITIN's Alade organized intensive ICT training for girls and teachers in Anambra state. The impact was immense, drawing the attention of the executive governor of the state and later the president, who both presented awards. WITIN's currently running women pivoting resilience in the digital economy in Africa[18], an award winning partner2connect pledge and Teachers.ng; all impact students directly on STEM. Other global interventions also implemented by WITIN include the ITU (International Telecommunications Union) programs[19] like Girls in ICT Initiative marked every 4th Thursday in April yearly[20], which has been marked by WITIN since 2011[21]. In 2014, Intel, USAID and NetHope launched the Women and the Web Alliance, a public-private partnership, at the First Ladies Forum during the U.S./Africa Leaders' Summit at the White House. Partners of this project included World Vision, World Pulse, WITIN and UN Women[22]. The goal of the alliance was to boost digital literacy for women and girls amongst others. WITIN was also implementing partner for the Intel She Will Connect[23] and also introduced the global Technovation Challenge to Nigeria; running the program for four years across the country [24], [25] [26] and leading the first winning African team to Silicon Valley, California in 2013. In 2014, the first lady of Nigeria celebrated the 2013 winning team [27], [28] who were also presented at the European Parliament[29].[30] by the ITU. The girls built a mobile app for tracking traffic offenders. WITIN also implemented the Africa Code Week[31]. All of these initiatives have elements of intensive digital skills/literacy training in STEM related modules.

These STEM hands-on trainings are usually handled by STEM experts with girls immersed in learning environments that enhanced collaboration and building of STEM social capital. The competitions seek interdisciplinary approaches to solving societal pressing problems and are rare opportunities for underrepresent students as described by [32], to gain knowledge and skills from subject experts in STEM.

CASUAL OBSERVATIONS

WITIN embarked on casual observations and assessment of 553 schools across the 6 geopolitical zones in Nigeria that have participated in WITIN's implemented or managed STEM programs for over a decade. Below are critical observations:

Observation1: Several schools do not fully utilize stem resources available to them**.** The federal government through agencies like the Nigerian Communications Commission (NCC) and Nigeria Information Technology Development Agency(NITDA) has provided STEM infrastructures, especially PCs to several secondary schools, including those in underserved communities. Unfortunately, a number of these schools do not optimally utilize these resources. Some even keep them under lock and key because they are afraid of getting PCs damaged. Others do not have skilled teachers or instructors to handle the computer labs.
Observation2: Slow learners as well as those with learning difficulties and disabilities are often excluded from full participation in hands-on STEM programs**.** Some public schools engage consultants and NGOs to teach students weekly, the duration of classes are usually too short to accommodate the learning paces of most students. Where schools are required to participate in competitions, some teachers select same students for every opening. Most of these competitions are preceded by at least three days intensive bootcamps. For mixed schools of boys and girls, some girls often feel intimidated by boys when it comes to hands-on learning as teams.
Observation 3: Some schools are unaware of open source and low cost readily available STEM resources **.** A school in eastern Nigeria for example, has over 2,000 students but just one Lego® Mindstorms® Ev3 robot for teaching. The components of the hardware are often delicate, which makes it difficult for students to practice hands-on freely, for fear of making mistakes or damaging components; as one lost piece could imply failure of an entire project. However there are several low cost and open source options including online simulators for teaching AI or STEM in general, with the same learning objectives.
Observation 4: Some schools teach hands-on STEM in only one grade**.** For schools offering such training in SSS2 (grade 11) for example, it would take 5 years for a student in JSS1(grade 7) to participate in such trainings.
Observation 5: Students are generally not encouraged to take risk .The teachers know that it would be difficult to replace damaged items due to risk taking and hence would rather opt for exclusion.
Observation 6: Not many schools have embraced teamwork and collaborative hands-on project based learning for STEM programs**.**
Observation 7: Some schools have majority of students unable to communicate their ideas aesthetically and effectively. A lot of students have not mastered the art of communicating, even when they have excellent ideas and solutions. Learners who passed through WITIN's visual literacy program[33]–[35] in a given school were able to express themselves better by employing visuals to aid their presentations compared to those who did not pass through any training.

THEORETICAL FRAMEWORK

Understanding frameworks for operationalization of STEM to enhance classroom practices is critical for educators, as reflected in the model presented by [36] . The framework was built on comparison of STEM education approaches and systematically contextualizing STEM from a well-defined research and holistic perspective but without inclusion underpinning. Some models focus on STEM teachers education and [37] gave an excellent overview of five of such models. [3] [4]derived models representing common goals and recommended strategies for inclusive STEM schools models; but contextualized to the United States. Several researchers have also engaged on inclusive STEM studies, however, these literatures lack the basis for contextualization to fit our work. This empirical study therefore hinges on Pacey's model which provides a generalised conceptual framework that is easily contextualizable. It describes technological practices as 3-faced comprising cultural, organizational and technical components, which appropriately explains and support our hypothesis. [3] used Pacey's framework to propose a model highlighting the effective integration of technology that supports STEM behaviours, knowledge and skills as requiring the intertwining of the aforementioned trio. We use the framework of [3] built on Pacey's, as a theoretical base to propose an Epistemological Framework comprising 7 components mapped to the trio as shown in figure 1.

HYPOTHESIS

Responding to our seven casual observations, we hypothesize(H1-H7) as follows:
Optimize resources – H1: STEM resources(e.g. computers, robot kits, iot devices, etc) should be utilized optimally and made available to teachers and students in the school as often as possible, at shifts when necessary.
Include All – H2: All students should be given equal opportunities to STEM training and resources.
Slow learners and students with learning difficulties should be given opportunities to participate in external STEM bootcamps. Slots should be provided for slow learners and students with learning difficulties and disabilities to accompany selected teams for hackathons and competitions as resources permit (they may not compete). Schools without skilled instructors can nominate teachers to be trained by NGOs, private consultants, the government or any other stakeholder offering such services; especially when they are free. Both males and females should be given equal opportunities and treated equally during hands-on STEM programs.
Improvise – H3: Schools with limited or no STEM resources should be encouraged to utilize open source and free/available/low-cost materials to teach STEM hands-on
Dynamize – H4: All grades(7-12) should be allowed to pass through STEM trainings within the same season as technology evolves and changes fast. While waiting for them to get to a particular grade, technology may have become obsolete.

Encourage risk-taking – H5: Teachers and students should be encouraged to explore with STEM resources; take risks and make mistakes to spur innovation

Collaborate – H6: Students should be encouraged to work in teams for hands-on STEM programs and share limited resources in groups. Teams should be diverse (students from different backgrounds, with diverse perspectives to spur innovations and inventions that serve diverse populations)

Communicate aesthetically – H7: Students should be equipped [able] to communicate their inventions and innovations visually; as arts is now critical to STEM. STEAM = STEM + arts

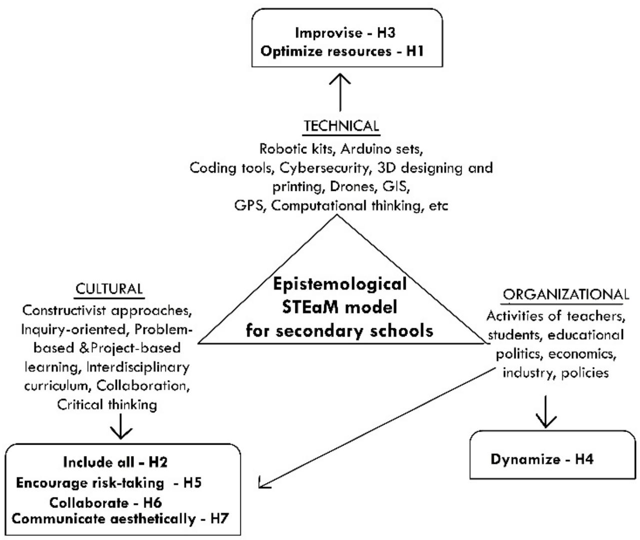

FIGURE I

SIMPLE STEAM MODEL MAPPED TO DACEY'S [THEORETICAL] FRAMEWORK

STEM to STEAM

Educator-scientists use visual arts to infuse creativity in students in STEM[38] as most scientists have to generate diagrams to communicate effectively. Visual literacy helps students tell their stories[34] and is fast becoming mandatory in this era of advanced visualizations and design thinking [39]. STEaM also increase student engagement, improves problem solving skills as well as innovation [40]. It encourages interdisciplinarity, and hence serves as an attraction for girls to STEM.

METHODOLOGY

The research design for this study employs a mixed method approach. First, we hypothesize after casual observations, then propose a framework. We then test the model by investigating the perceptions of both teachers and students on our propositions using quantitative online survey. We map questions(Q) to hypotheses as shown in table 1 .

TABLE I

MAPPING OF QUESTIONS TO HYPOTHESES

Questions	Hypotheses	
Q1	Optimize resources	H1
Q2 Q3, Q4, Q5, Q6	Include all	H2
Q7	Improvise	H3
Q8	Dynamize	H4
Q9	Encourage risk-taking	H5
Q10	Collaborate	H6
Q11	Communicate aesthetically	H7

Participants and Research Instruments

Teachers and students who have participated in the digital girls' club bootcamps and competitions were surveyed for this study. Only teachers in the club's WhatsApp group, were invited to participate in the survey. They were provided with a brief description of study. Information on privacy, consents, confidentiality and incentives; followed by a link to the survey hosted on Google Cloud, was sent to them as well. The link for students' participation were made available to the teachers to send to their students. A total of 36 teachers and 178 students filled the online survey. All students' respondents were females. Permission from the FMoCDE's department of planning research and statistics was granted. All data were anonymized to protect the privacy of participants for analysis and public availability[41].

The survey comprises some demographic questions such as geopolitical zones of schools as well as 11 key questions on 5-point Likert scale as shown in table 3. Only students who had access to internet connectivity at the time of data collection and who also provided parental consent, were able to participate in this study.

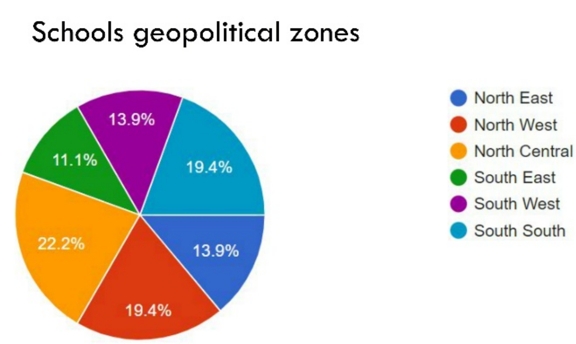

FIGURE 2

THE GEOPOLITICAL ZONES OF TEACHERS WHO PARTICIPATED IN STUDY

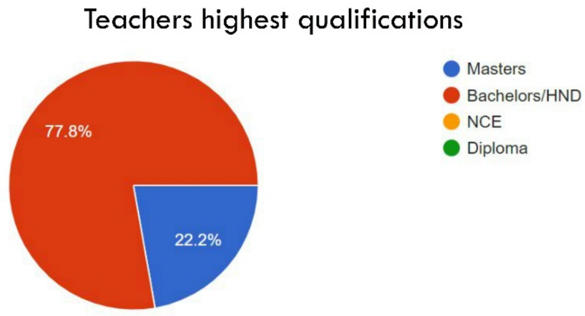

FIGURE 3
HIGHEST QUALIFICATIONS OF TEACHERS IN THE DIGITAL GIRLS CLUB WHO PARTICIPATED IN THIS STUDY

Data analysis

Survey data is analysed using R [42]. First, we test for the homogeneousness of variance in the two groups using Levene's test (center = mean) .

$$H_0: \sigma_S = \sigma_T$$
$$H_1: \sigma_S \neq \sigma_T \quad (1)$$

σ_S is the variance of students' response to a question
σ_T is the variance of teachers' response to a question

TABLE 2
LEVENE'S TEST FOR HOMOGENEITY OF VARIANCE FOR Q1-Q11

Questions	Teachers' Mean	Students' Mean	p-value
Q1	4.416666667	4.764044944	2.347E-07
Q2	4.388888889	4.820224719	2.921E-07
Q3	4.277777778	4.528089888	7.796E-04
Q4	3.888888889	4.410112360	1.627E-04
Q5	3.111111111	4.168539326	4.405E-04
Q6	3.916666667	4.651685393	7.100E-06
Q7	4.305555556	4.662921348	4.920E-04
Q8	4.222222222	4.646067416	1.919E-03
Q9	4.305555556	4.359550562	1.310E-01
Q10	4.472222222	4.786516854	1.25E-06
Q11	4.055555556	4.528089888	9.35E-04

The variances of both groups from Q1 to Q11 were heterogenous except Q9, hence we use the Welch t-test, the default in R for testing two independent unequal sample sizes with unequal variances.

To test the equality of means for the groups.

$$H_0: \mu_S = \mu_T$$
$$H_1: \mu_S \neq \mu_T \quad (2)$$

H_0 is the null hypothesis
H_1 is the alternative hypothesis
μ_S is the mean of students' responses to a question
μ_T is the mean of teachers' responses to a question

FINDINGS AND DISCUSSIONS

Results are shown for 36 teachers and 178 students who participated in this study and responded to the 11 key questions(Q1-Q11) as in table 3 and figure 4.

TABLE 3
WELCH TWO SAMPLE T-TEST FOR Q1 – Q11 AT 95% CONFIDENCE INTERVAL

Questions	t	df	p-value	Reject H_0
Q1	1.7703	37.679	0.084760	No
Q2	2.4135	38.120	0.020710	Yes
Q3	1.1615	39.272	0.252400	No
Q4	2.1473	39.834	0.037910	No
Q5	3.7841	44.066	0.000462	Yes
Q6	3.1372	39.899	0.003201	Yes
Q7	1.7439	39.730	0.088900	No
Q8	2.1804	40.520	0.035090	Yes
Q9	0.2399	42.834	0.811600	No
Q10	1.7516	37.911	0.087930	No
Q11	2.2150	39.598	0.032580	Yes

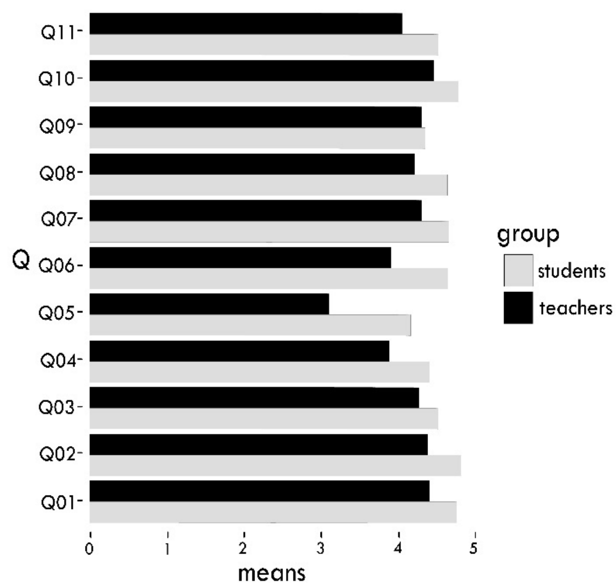

FIGURE 4
MEANS OF REPONSES TO QUESTIONS BY STUDENTS AND TEACHERS

Table 3 shows the evaluated Welch t-test values for survey questions Q1-Q11 for both groups, to determine if there was a statistically significant difference between the two groups' perceptions of our propositions. Significant differences in their responses' means were detected for Q2, Q5, Q6, Q8 and Q11 as the null hypothesis was rejected for these questions. For Q2 the students agree more that "all students should be given equal opportunities to STEM training and resources" even though both means are above 4.0 . The teachers understood the hassle involved in using limited resources hence.

Q5 is a tricky question with the lowest p-value and also lowest means for both teachers and student. There is a significant difference in the perception between both groups on employing the services of NGOs and private consultants to teach hands-on STEM in schools, instead of training less skilled teachers as STEM Instructors. Only 50% of teachers agree/strongly agree, compared to 81% for students. While the students are somewhat contended having the services of NGOs and private consultants to teach hands-on STEM in their schools, it is not a sustainable and inclusive solution in the long term, especially for resource-poor schools. Such external hands would not be able to spend quality time with learners and would be more expensive in the long run. This explains why the rating is low for teachers, who have better understanding of the challenge; thus further validating our proposition on the need for training less skilled teachers as STEM Instructors in underserved schools, to augment external instructors where applicable. Underserved schools can seek for the services of NGOs like WITIN rendering hands-on STEM programs for free. However, teachers should take advantage and learn from such NGOs, so that they can continue to run the programs after the NGOs discontinue services, as fundings for such programs are limited.

For Q6, 93.2% of the students believe both males and females are given equal opportunities and treated equally during hands-on STEM programs; compared to 72.2%. of teachers. This could be as a result of most of the students having never had the opportunity of learning together with boys as all students in this study are girls who are mostly from girls-only schools.

For Q8, 91% of students agree/strongly agree all grades(7-12) should be allowed to pass through STEM trainings as technology evolves and changes fast; compared to 86.1% of teachers who feel same way. Both values are not too far apart(p-value=0.04) even though we rejected H_0 .

For Q11, 89.30% of students and 80.50% teachers agree/strongly agree that students should be able to communicate their inventions and innovations visually as arts is critical to STEM in this era.

No Significant differences in the perceptions of teachers and students was detected for Q1, Q3, Q4, Q7, Q9 and Q10 as we failed to reject the null hypothesis for these questions. With the exception of Q4, over 80% of both groups agree/strongly agree as follows:

Q1: STEM resources should be utilized optimally and made available to teachers and students in the school as often as possible, at shifts when necessary;

Q3: Slow learners and students with learning difficulties should be given opportunities to participate in external STEM bootcamps;

Q7: Schools with limited or no STEM resources should be encouraged to utilize open source and free/available materials to teach STEM hands-on;

Q9: Teachers and students should be encouraged to take risks, explore with STEM resources and make mistakes to spur innovation and finally

Q10: Students should be encouraged to work in teams for hands-on STEM. Teams should be diverse (students from different backgrounds, with differences).

The mean of Q4 for teachers is 3.9 as only 47.7% of teachers (compared to 88.2% for students) agree/strongly agree that slots should be provided for slow learners and students with disabilities/learning difficulties, to accompany selected teams for hackathons and competitions if resources permit. This question is the crux of this study as this group of marginalized students have been grossly excluded from opportunities in STEM over time. The teachers' poor responses clearly show that more teachers are unwilling to go the extra mile to accommodate these marginalized students. **It may require policy enforcement to ensure their inclusion**. Both teachers and students agree/strongly agree on all other questions/propositions including Q11 which addresses the importance of arts in STEM to STEaM.

All means of student responses were above 4 with range 4.1-4.9 while range for teachers is 3.1 – 4.6. The students are generally in agreement with our propositions 1-7 of this study. Both students' and teachers' means are highest for Q10. Students =4.8 and teachers=4.5; which obviously imply both agree on collaboration, teamwork and diversity.

CONCLUSION

Our empirical findings show strong validation of our propositions by teachers and students surveyed. This study therefore proposes an epistemological STEaM model as shown in figure 5. It comprises seven contributions as follows: Optimize resources, Include all, Improvise, Dynamize, Encourage risk-taking, Collaborate and Communicate aesthetically. This framework would serve **as** potential policy instrument to enforce inclusion in hands-on STEM programs by schools. It will also guide the implementation of sustainable hands-on programs for schools with limited resources as well as create awareness on the importance of aesthetics (arts) for effective communication of STEM ideas and outcomes.

This model would also serve as a policy instrument reduce the general digital/STEM divide as well as enforce the optimization of limited resources.

Future study could explore inclusion of boys' perspectives as well as participants from mixed schools.

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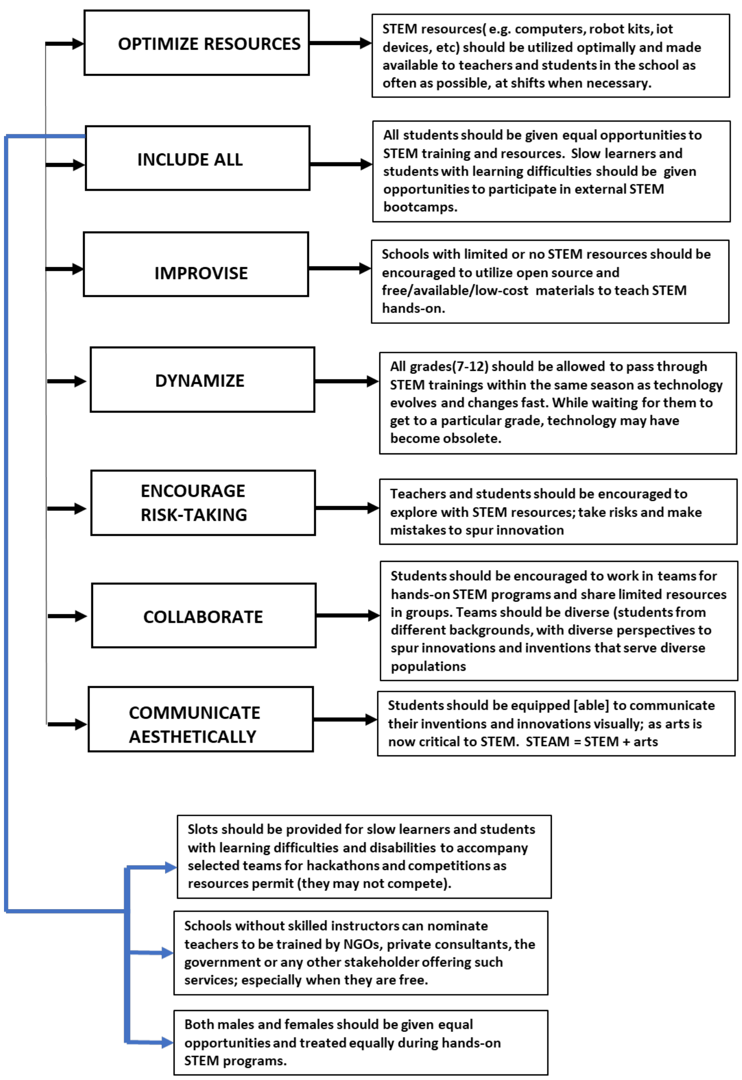

FIGURE 5
AN EPISTEMOLOGICAL STEAM MODEL FOR HANDS-ON STEM PROGRAMS IN UNDERSERVED SECONDARY SCHOOLS[43]

TABLE 4
SURVEY QUESTIONS Q1 – Q11 AND RESPONSES

Questions		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Group
(Q1)1. OPTIMIZE RESOURCES	STEM resources(e.g. computers, robot kits, iot devices, etc) should be utilized optimally and made available to teachers and students in the school as often as possible, at shifts when necessary.	0 %	0.6%	1.7%	18.5%	79.2%	Students
		8.3 %	0 %	2.8 %	19.4 %	69.4 %	Teachers
(Q2)2a. INCLUDE ALL	All students should be given equal opportunities to STEM training and resources.	0.6%	0%	1.1%	13.5%	84.8%	Students
		5.6 %	2.8 %	0 %	30.6%	61.1%	Teachers
(Q3)2b. INCLUDE ALL	Slow learners and students with learning difficulties should be given opportunities to participate in external STEM bootcamps	0%	1.7%	5.6%	30.9%	61.8%	Students
		11.1%	0%	0%	27.8%	61.1%	Teachers
(Q4)2c. INCLUDE ALL	Slots should be provided for Slow learners and students with disabilities/learning difficulties to accompany selected teams for hackathons and competitions if resources permit (they may not compete)	1.1%	1.7%	9.0%	31.5%	56.7%	Students
		13.9%	5.6%	2.8%	3.3%	44.4%	Teachers
(Q5)2d. INCLUDE ALL	I believe its effective employing the services of NGOs and private consultants to teach hands-on STEM in schools instead of training less skilled teachers as STEM Instructors	8.4%	3.9%	6.7%	24.2%	56.7%	Students
		22.2%	22.2%	5.6%	22.2%	27.8%	Teachers
(Q6)2e. INCLUDE ALL	I believe both males and females are given equal opportunities and treated equally during hands-on STEM programs	1.7%	2.2%	2.8%	15.7%	77.5%	Students
		11.1%	5.6%	11.1%	25%	47.2%	Teachers
(Q7) IMPROVISE	Schools with limited or no STEM resources should be encouraged to utilize open source and free/available materials to teach STEM hands-on	0.6%	1.7%	3.4%	19.7%	74.7%	Students
		8.3%	2.8%	0%	27.8%	61.1%	Teachers
(Q8) BE DYNAMIC	All grades(7-12) should be allowed to pass through STEM trainings as technology evolves and changes fast. While waiting for them to get to a particular grade, technology may have become obsolete	0	2.2%	5.6%	17.4%	74.7%	Students
		5.6%	5.6%	2.8%	33.3%	52.8%	Teachers
(Q9) ENCOURAGE RISK-TAKING	Teachers and students should be encouraged to explore with STEM resources and make mistakes to spur innovation	1.1%	5.6%	8.4%	25.8%	59%	Students
		11.1%	0%	2.8%	19.4%	66.7%	Teachers
(Q10) COLLABORATE	Students should be encouraged to work in teams for hands-on stem. Teams should be diverse (students from different backgrounds, with differences)	0%	0.6%	1.1%	17.4%	80.9%	Students
		5.6%	2.8%	0%	22.2%	69.4%	Teachers
(Q11) COMMUNICATE (AESTHETICALLY)	Students should be able to communicate their inventions and innovations visually. So arts is critical to STEM. (STEAM) = STEM + arts	0%	0.6%	10.1%	25.3%	64%	Students
		8.3%	5.6%	5.6%	33.3%	47.2%	Teachers

Summary extracted from google form. Some entries may not total 100%