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THE EFFECT OF PRACTICAL WORK AND MOTIVATION ON STUDENTS' DESIRE TO STUDY STEM SUBJECTS

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Abstract

STEM is the foundation of all disciplines, yet fewer students are interested in pursuing such subjects due to fear and 'difficulty' associated with them. The Ghana Association of University Women (GAUW), the Ghana branch of Graduate Women International (GWI), believes that Motivation through various activities is key in solving such challenges. "Motivation refers to an inner drive to action that, in terms of observable consequences, might manifest itself in a pupil's decision" to actively study STEM subjects.

There have been claims concerning the motivational worth of practical work, as students' engage in both in and out laboratory activities to pursue science and mathematics related courses as they climb the academic ladder. This is a very useful means of evaluating the degree to which such assertions are reinforced by the facts. The purpose of this study was to ascertain if motivating Junior High School (JHS) students through talks and practical experiments on STEM subjects would remove the fear of STEM subjects.

Respondents (79) were asked about their interest and perception about STEM subjects before and after the science clinic. The descriptive analysis revealed that JHS students' interest in STEM subjects and the desire to study these subjects increased after participating in the programme. Those students who initially disliked the subjects and those who were neutral on whether they will pursue STEM subjects in Senior High School (SHS) or in the future changed their mind. Numbers shot up especially for mathematics (the most feared subject).

Interest in Science, Technology, Engineering and Mathematics can be boosted by motivational activities (talks, tours, etc) and practical learning (laboratory work, reading exercises, etc).

Keywords: STEM, Practical Work, Motivation, Fear, JHS Students, GAUW, GWI

1 INTRODUCTION

The STEM curriculum is based on the idea of teaching students in four particular disciplines namely; Science, Technology, Engineering and Mathematics [1]. In Ghana and elsewhere in the world, the science is an integration of four key areas namely; biology, chemistry, physics and agriculture which the Ghanaian curriculum refers to it as integrated science. Also, the technological part of STEM is emphasized in Information and Communication Technology (ICT) which is also part of the curriculum then the mathematics.

STEM as the foundation of all disciplines has also been referred to as "gateway into many fields" [2]. STEM is embedded right from the basic and elementary stages of education in Ghana. Education in STEM builds great thinkers, intensifies science learning and creates an enabling environment for innovation and problem solving. This innovation spearheads new products and methods that help us put-up-with the demands of the economy. Thus, the driving force for innovation and science literacy relies on unquestionable knowledge in STEM disciplines. Hence, all future jobs require a basic understanding of science and mathematics. An added advantage is that those who graduate with STEM degrees receive much higher salary even in non-STEM professions.

The fore-mentioned benefits make STEM a driving force for the sustainability of our world yet fewer students, whether male or female, pursue it at higher stages of education. In Ghana, STEM is compulsory at the basic and elementary level hence, the actual decline begins from the senior high level of education. Additionally, the problem is compounded because females shy away from the subject areas and this has been a historic phenomenon which Chonghui [2] emphasis in his research. Walport [3] argues that, in US and UK, although some continue to think science is not important in higher education, interventions are working gradually than in Africa. Some factors contributing to this decline are

- **Fear (from what parents/adults say).**
- Method of Teaching (no motivation, no/few practical) in Ghana (Africa).
- Inadequate Resources (labs, computers, materials, etc) in Ghana (Africa).

Research has found that motivation is key in encouraging our younger generation to study STEM subjects. Bandura [4] defines motivation as “an inner drive to Action’ that, in terms of observable consequences, might manifest itself in a pupil's decision to actively pursue the study of one, or more, science subjects in the post-compulsory phase of their education, or additional voluntary actions undertaken by the pupil”. These activities (out laboratory) include:

- Science club activities, mentorship program (public speaking).
- Going the extra mile with one’s homework.
- Key interest in science books/magazines.
- Science based programmes (tablet, television and web sites).
- Interest in Scientific tours, field trips, etc.

Motivation and practical work is key in STEM and this has been supported by many researchers [5], [6], [7], [8]. Many reasons for doing practical work in school science and maths is evident in research [4], [9], [10], [11]. The most commonly mentioned by instructors include:

- “To encourage accurate observation and description”.
- “To make phenomena more real”.
- “To arouse and maintain interest”.
- “To promote a logical and reasoning method of thought”.

The Ghana Association of University Women-GAUW (Ghana Chapter Of Graduate Women International-GWI) has mandated herself in championing the course of mentoring junior high students around the University of Cape Coast communities (in Ghana) who are deprived in terms of resources that enhance the learning of STEM subjects. This research draws heavily on the organized Science Clinic in September, 2018 to encourage students (more girls than boys) in continuing to study mathematics and science as they climb the academic ladder. They help the student to practice the theory they learnt in school in the university Laboratories whiles emphasizing the use of improvised materials (used) around them. The motivational program includes other activities such as science educational tours, motivational talks and seminar on the art of public speaking, maths and science quiz competition, math and science project which test innovation and creativity using knowledge in STEM, among others.

Therefore, this study seeks to find out if the motivational and science/Math clinic program organized had any effect on the students’ desire to pursue STEM subjects in the future. Specifically, the research wants to find out (before and after the program):

- Students’ most preferred science subject.
- Students’ most preferred STEM subject.
- Whether students’ preference of STEM subjects differ across gender.
- Whether a students’ likeness of a subject mean they will study the subject.
- If there is an association between students likeness of a subject and the desire to study the said subject.

- Whether there exist significant differences between agreed pre-responses and agreed post responses across all items.
- Whether there exist significant differences between disagree pre-responses and disagree post responses across all items.

The aforementioned objectives will help us to verify if there are improvements in participants desire (short term) to pursue STEM in the future regarding the STEM motivational program being organised and also serve as a form of evaluation towards future planning and organization of the program. It will also serve as a reference for other educational institutions or NGOs or governments to adopt in policy implementation to enhance continuity of STEM.

2 METHODOLOGY

This Quantitative study explored the nature of junior high school students' experiences is purely an evaluation research since it sought to measure the effectiveness of a program. The target population was taken from 4 deprived schools around the University of Cape Coast community.

Twenty students were selected from each school and were being mentored already. The mentoring program also covers non-STEM activities such as English literacy and writing skills, writing competitions (story writing and public speaking), one-on-one mentoring, talk on other social vises (rape, kidnapping, etc.).

The instrument used in the data collection was a structured questionnaire. A total of 198 (79 in pre survey and 79 in post survey) independent samples were collected. One student did not answer all the questions, hence was excluded from the analysis. The Assessment was based on motivational talk, laboratory practical and field trip.

3 RESULTS AND DISCUSSIONS

General data was explored in the preliminary analysis and based on the findings; further test was carried out in the further analysis.

3.1 Preliminary Analysis

A total of 80 students participated in both the pre and post survey but one student could not answer all the items in the questionnaire. Table A1 in Appendix A shows that, out of the 79 students who completed their questionnaire, 53 (67.1%) were female and 26 (32.9%) were male. Table A2 (see Appendix A) shows that out of the 79 students, 1 student did not indicate his form but majority (48.7%) of the students were in JHS3, 35.9% were in JHS2 and the remaining 15.4% are in JHS1.

3.1.1 Assessment on Mathematics

Table 1: I like Mathematics

Pre Analysis			Post Analysis		
	Frequency	Percent		Frequency	Percent
Disagree	10	12.7	Disagree	3	3.8
Neutral	10	12.7	Neutral	9	11.4
Agree	59	74.7	Agree	67	84.8
Total	79	100.0	Total	79	100.0

Students' likeness for mathematics appreciably improved after the program (see Table 1). Students initially did not like mathematics at all (12.7%) and also some were undecided (12.7%) about their interest but after the mathematical practical and motivational talk, only 3 students (3.8%) and 9 students (11.4) remained in the disagreed and neutral category, respectively. Thereby increasing the likeness of

mathematics from 74.7% to 84.8%.Even in the short term, the program has made some appreciable positive impact.

Further, students were asked if they would want to study mathematics in the future (senior high school level) and there were positive change in their responses. The fact is the Ghanaian Senior High School(SHS) curriculum requires each JHS student, having studied all subject at the elementary level, select among the various programs (Science, Arts, Visual Arts, Home Economics, Technical and Vocational, etc.). Definitely the number of students who might like mathematics or any of the science programs may have to select one and only one program (subject) when enrolling in SHS or vocational school.

Table 2 depicts those who agreed before and after the program to study mathematics in future. Thus the pre-desire was increased by 1% in the post-desire. Interestingly, some of those who disagree to do mathematics in the future in the pre-analysis (8.1%) moved to the neutral position thereby reducing (5.1) their refusal to consider mathematics in future. This surely is a great plus to at least think about it.

Table 2: I want to study Mathematics

Pre Analysis			Post Analysis		
	Frequency	Percent		Frequency	Percent
Disagree	7	8.9	Disagree	4	5.1
Neutral	27	34.2	Neutral	29	36.7
Agree	45	57.0	Agree	46	58.2
Total	79	100.0	Total	79	100.0

3.1.2 Assessment on Science (integrated)

The likeness and desire to study science subjects also generally increased in the post-analysis. Thus, the study explored the most preferred science subject by students by comparing their likeness for each subject. Table3 shows that before the program (pre analysis), students prefer Biology mostly since 62(79.5%) of the students agreed to like Biology. Also, the least preferred science subject (49 students (62.8%)) before the program was Agriculture. After the program, students' preference changed from Biology being highest to Chemistry. 70(89.7%) students prefer Chemistry and even though agriculture again recorded the least there was some improvement in the post analysis.

Table 3: Science subject preferred mostly by students

	Pre Analysis			**Post Analysis**		
	Agree	**Neutral**	**Disagree**	**Agree**	**Neutral**	**Disagree**
Chemistry	55(70.5%)	16(20.5%)	7(9%)	70(89.7%)	6(7.7%)	2(2.6%)
Physics	52(65.8%)	22(27.8%)	5(6.3%)	63(80.8%)	12(15.4%)	3(3.8%)
Agriculture	49(62.8%)	14(17.9%)	15(19.2%)	52(66.7%)	16(20.5%)	10(12.8%)
Biology	62(79.5%)	10(12.8%)	6(7.7%)	64(82.1%)	12(15.4%)	2(2.6%)

Students like ICT but their interest in the subject remains the same after the post- analysis (see Tables B3 and B4 in Appendix B). Unlike other subject, ICT is studied as a core subject and it is compulsory even at the SHS level. Thus, the study is looking at the elective aspect of the subjects or programs. Majority (83.5%) of the students claim STEM subjects are practical in the pre-analysis as compared to 87.3% in the post-analysis. Meaning their dislike has reduced and those who were neutral have also slightly increased. Subsequently (see Appendix B), the research found out if STEM subjects were fun and interesting. In response, 62% agreed in the pre-analysis but after the program, 6% increase. Again, those who disagreed reduced drastically and they either agreed or remained neutral (see Appendix B, Tables B5 and B6) after the program.

3.1.3 Cross-tabulation on General Comparisons

The exploration so far has revealed differences in preference level across all subjects by students. The study continues to further investigate such differences in likeness or dislike for these subjects across

gender. Since females are in the majority, the average score of dislike or like for a particular subject is more than that of males even for those who chose to remain neutral but the percentages reveal the relative differences correctly.

Table 4 and 5 reveals that the proportion of students who dislike mathematics, integrated science and ICT decreased considerably from pre (28%, 13% and 15%) to post (9%, 8%, 4%) analysis respectively in the female category. Whilst in the male category, the proportions were from (32%, 20% and 12%) to (6%, 2% and 4%). Students who did not dislike any of the subjects were in the majority in both the pre and post programs. The likeness for the subjects increased from 43.4% to 60.4% in the female category whilst that of male increased from 36% to 50% respectively. This results emphasis the value of the program even though it was not in existence for long (see Table 4 and 5).

Table 4 (Pre): Gender against Science subject Disliked by students

		Science subject dislike				
		Mathematics	Int. Science	ICT	None	Total
Gender of Students	Female	15(28.3%)	7(13.2%)	8(15.1%)	23(43.4%)	53(100%)
	Male	8(32.0%)	5(20.0%)	3(12.0%)	9(36.0%)	25(100%)
	Total	23(29.5%)	12(15.4%)	11(14.1%)	32(41.0%)	78(100%)

Table 5 (Post): Gender against Science subject Disliked by students

		Science subject dislike				
		Mathematics	Int. Science	ICT	None	Total
Gender of Students	Female	9(17.0%)	8(15.1%)	4(7.5%)	32(60.4%)	53(100%)
	Male	6(25.0%)	2(8.3%)	4(16.7%)	12(50.0%)	25(100%)
	Total	15(19.5%)	10(13.0%)	8(10.4%)	44(57.1%)	78(100%)

Secondly, the study found out how males and females fared in terms of their favourite subjects.

Table 6 also revealed that in the pre-analysis, females' most preferred subject is integrated science (61.5%) whereas that of the males is Mathematics (42.3%).

Table 6 (Pre): Gender against Favourite Science Subject

		Favorite science subject			
		Mathematics	Int. Science	ICT	Total
Gender of Students	Female	13(25.0%)	32(61.5%)	7(13.5%)	52(100%)
	Male	11(42.3%)	6(23.1%)	9(34.6%)	26(100%)
	Total	24(30.8%)	38(48.7%)	16(20.5%)	78(100%)

In the post-analysis, the females' maintained integrated science as their favourite subject with a slight decrease (51%) but their interest in mathematics improved (25%-31.4%). In the male category, interest in STEM switched from mathematics to ICT (see Table 7). This suggests that boys have an affinity for electronic and computerized gadgets and females might have affinity for mathematics if given a favourable environment.

Table 7 (Post): Gender against Favorite science subject

		Favorite science subject			
		Mathematics	Int. Science	ICT	Total
Gender of Students	Female	16(31.4%)	26(51.0%)	9(17.6%)	52(100%)

	Male	8(32.0%)	5(20.0%)	12(48.0%)	26(100%)
	Total	24(31.6%)	31(40.8%)	21(27.6%)	78(100%)

The aforementioned observations suggest vast differences in preference for STEM subjects and their desire to pursue them. In the next section, we investigate if these differences are really statistically significant.

3.2 Further Analysis

1. Ho: ***There exists no significant relationship b/n gender and STEM subject disliked.***

H_A: ***There exists significant relationship b/n gender and STEM subject disliked.***

2. Ho: ***There exists no significant relationship b/n gender and favourite STEM subject.***

H_A: ***There exists significant relationship b/n gender and favourite STEM subject.***

In both the pre and post analysis, the difference in the dislike of STEM subjects by female students and male students is not significant (see chi-square test in Appendix C, Table C7 & C8). Alternatively, the difference in the favourite STEM subjects between the female students and male students is significant (see chi-square test in Appendix C, Table C9 & C10). Thus, for favourite subjects, females differ in their choice from males and they all agree STEM subjects are practical irrespective of their gender.

The study has based its major conclusions on the pre-agreed/disliked responses and post-agreed/disliked responses so as to verify whether the objective of the program was realised. This is to see if the students will change their mind-set after going through a motivational and practical STEM activity.

Validation 1:

Ho: There is no significant difference between Pre Agreed count and Post Agreed count.

H_A: ***There is a significant difference between Pre Agreed count and Post Agreed count.***

```
Paired T for Pre Agreed count - Post Agreed count

                        N   Mean  StDev  SE Mean
Pre Agreed count       14  52.21   8.29     2.21
Post Agreed count      14  57.71   6.79     1.81
Difference             14  -5.50   6.60     1.76


95% CI for mean difference: (-9.31, -1.69)
T-Test of mean difference = 0 (vs not = 0): T-Value = -3.12  P-Value = 0.008
```

Figure 1: Paired T for Pre Agreed count Vs Post Agreed count

Fig 1 implies that *truly there have being an increment in students Agreeing to want to study STEM subjects and likeness of STEM subjects after the program was over. The validation was also repeated for disliked responses in Fig 2.*

Validation 2:

Ho: There is no significant difference between Pre Disagreed count and Post Disagreed count.

H_A: ***There is a significant difference between Pre Disagreed count and Post Disagreed count.***

```
Paired T for Pre Disagreed count - Post Disagreed count

                          N  Mean  StDev  SE Mean
Pre Disagreed count      14  8.29   4.41     1.18
Post Disagreed count     14  4.43   2.95     0.79
Difference               14  3.86   4.69     1.25


95% CI for mean difference: (1.15, 6.56)
T-Test of mean difference = 0 (vs not = 0): T-Value = 3.08  P-Value = 0.009
```

Figure 2: Paired T for Pre Disagreed count Vs Post Disagreed count

Fig 2 implies that truly there have being a decrement in students Agreeing to want to study STEM subjects and likeness of STEM subjects after the program was over.

4 CONCLUSIONS

Based on the objectives of the study, the following conclusions were drawn:

The Most preferred STEM subject was integrated science. This decreased after the program for females and their preference went up for mathematics. Generally, ICT had an increment (especially for males). Biology was the most preferred in the Pre analysis and chemistry was the most preferred after the program. All subjects had improvements in students' likeness after the program. This is confirmed by the fact that Majority of students did not dislike any of the subjects in both Pre and especially in the Post analysis. Although Mathematics was not the favourite, dislike for STEM subject decrease immensely after the intervention. Further test revealed that, there was a significant association between likeness and the desire to study Mathematics, Science and ICT across both Pre and Post Analysis using 10%, 5% and 1% level of significance respectively. Although, there exists no significant relationship between gender and STEM subject disliked, there exists a significant relationship between gender and favourite STEM subject. The increment in students' agreeing to want to study STEM subjects and likeness of STEM subjects after the program was significant. Likewise, there was a significant decrement in students' disagreeing to want to study STEM subjects and dislike of STEM subjects after the program. Both forward and backward validations of responses before and after the program were all significant.

It is therefore recommended that:

- Motivational programs (talks, lab practicals, science tours, quizzes, etc) are key in keeping the interest of students in STEM.
- Mentorship programs are key in encouraging and ensuring mentees' sustained progression in STEM education and career (especially females).
- FEAR of Mathematics, Science, ICT can only be erased by positive action and motivation by all stake holders (especially **parents** and teachers).
- We encourage all teachers especially those in Africa (Ghana) to make their teaching very practical and beat cost by using improvised materials around them to illustrate STEM subjects.
- After five years, further research should be conducted to ascertain whether the program has been effective in the long term given the short term was successful.

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5 APPENDICES

Appendix A: Demographic Statistics

Table A1: Distribution of Gender

	Frequency	Percent
Female	53	67.1

Male	26	32.9
Total	79	100.0

Field survey, 2018: (Pre & Post) same students

JHS1	12	15.4
JHS2	28	35.9
JHS3	38	48.7
Total	78	100.0
Missing	1	
Total	79	

Table A2: Form of Students

	Frequency	Percent

Appendix B: Preliminaries Analysis

Table B3 (Pre); I like to study ICT

	Frequency	Percent
Disagree	3	3.8
Neutral	17	21.8
Agree	58	74.4
Total	78	100.0
Missing	1	
Total	79	

Table B4 (Post); I like to study ICT

	Frequency	Percent
Disagree	5	6.4
Neutral	15	19.2
Agree	58	74.4
Total	78	100.0
Missing	1	
Total	79	

Table B5: All STEM Subjects are Practical

Pre Analysis			Post Analysis		
	Frequency	Percent		Frequency	Percent
Disagree	3	3.8	Disagree	1	1.3
Neutral	10	12.7	Neutral	9	11.4
Agree	66	83.5	Agree	69	87.3
Total	79	100.0	Total	79	100.0

Table B6: All STEM Subjects are Fun and Interesting

Pre Analysis			Post Analysis		
	Frequency	Percent		Frequency	Percent
Disagree	7	8.9	Disagree	1	1.3
Neutral	23	29.1	Neutral	23	30.3
Agree	49	62.0	Agree	52	68.4
Total	79	100.0	Total	76	100.0

Appendix C

Table C7 (Pre): Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.930[a]	3	.818
Likelihood Ratio	.916	3	.822
Linear-by-Linear Association	.479	1	.489
N of Valid Cases	78		

Table C8 (Post) Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.760[a]	3	.430
Likelihood Ratio	2.696	3	.441
Linear-by-Linear Association	.426	1	.514
N of Valid Cases	77		

Table C9 (Pre) Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.732[a]	2	.005
Likelihood Ratio	11.114	2	.004
Linear-by-Linear Association	.050	1	.822

N of Valid Cases	78

Table C10 (Post) Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.543[a]	2	.008
Likelihood Ratio	9.655	2	.008
Linear-by-Linear Association	2.477	1	.116
N of Valid Cases	76		