ABSTRACT

Poverty amongst women can be reduced significantly as more women embrace the male dominated skilled and high paying Science, Technology, Engineering and Mathematics (STEM) occupations. Only 24% of graduates in engineering, manufacturing and construction were women (OECD, 2018). Bridging the gender gap remains a global challenge to policy makers especially in Africa. The situation is worrisome considering the social implications. Digital technologies have been known to remove the need for face-to-face interactions in learning thus reducing the difficulties women face in male dominated STEM-TVET. The aim of study is to propose novel attracting and retaining strategies using digital technology solutions for increasing female students' enrolment and performance in STEM programmes in Technical, Vocational Education and Training (TVET) Institutions. Design of this study was descriptive survey and 109 STEM teachers across five TVET institutions in Africa participated in the study. Data was collected using questionnaire. A blend of existing curriculum with digital technology was infused into the sensitization framework. Well designed and specifically targeted policies were proposed together with the digital solutions to yield more robust outcomes. The results revealed that attracting strategies are crucial initiatives needed to increase students' enrolment in STEM education. The study recommends that governments and institutions should come up with policies which outline strategies to improve enrolment and retain female students undertaking STEM/TVET courses.

INTRODUCTION

The girl-child has made significant progress in education through marked increase in enrolment however, the same zeal has not been demonstrated in STEM courses. STEM (Science, technology, engineering, and mathematics) courses are generally considered as vital to regional and national economic growth.

UNESCO (2019 & 2017) report indicates that only 35% of STEM students in higher education institutions globally are women. Of these few women who choose STEM related fields; only 5% take natural science, mathematics and statistics, while 8% take engineering, manufacturing and construction, and 3% take information and communication technology. UNESCO 2017 report further reveals that, only 17 women have won a Nobel Prize in Physics, Chemistry or Medicine compared to 572 men (Amunga and Musasia, 2021).

The role of Africa as a key player in global economy is dependent on the drive to encourage more entrants into these fields. Africa as a whole lags behind in STEM education and careers with many students ranking poorly in math and science performance, respectively. African countries are generally the most affected by the unequal gender participation in STEM. This is why the African Union called on Africa's political leadership to address this anomaly in demonstration of seriousness about embracing STEM for transforming their societies (Kimotho, 2019). In West Africa, no country has reached the 25% mark for women researchers in sciences (Okeke, et al., 2017).

Encouraging women to pursue STEM education and careers will not only fill the critical (and well-paying) jobs but will also bridge the gap. So how can we make this happen? How can gender responsive pedagogy address the issues? Teachers play a key role in assisting students especially girls to take interest in science subjects and mathematics. Amunga and Musasia, 2021 reported weak scholastic performance as possible reasons for low women's participation in STEM

BACKGROUD OF STUDY

The bedrock of a career in STEM commences in elementary school but higher education institutions churns out the finished products. A number of factors have also been attributed to be responsible for the underperformance of females in STEM. The gender stereotyping of science as masculine and the cultural belief that females do not have the full cognitive capacity for learning science are some of the prevalent factors that contribute to gender gaps

The science laboratory plays a critical role in students' formation of science concepts because it provides avenue for students to acquire practical and hands-on skills for learning abstract concepts. Many African schools are confronted with inadequate Science laboratories and equipment thereby contributing to high failure rate in STEM (Akhigbe and

Adeyemi, 2020). The virtual laboratory has been identified as an effective pedagogical tool that can be incorporated into science instruction to enhance females' participation and achievement in science (Gambari, et al., 2017). Virtual laboratory uses computerized models to provide highly interactive virtual reality simulations of laboratory exercises. It is software designed to simulate the physical laboratory learning environment and provides students with interactive interface for conducting computer controlled experiments (Gambari, et al., 2017).

In the Africa Development Indicators report, the World Bank noted that over 80 per cent of urban people in Africa had access to mobile phones; this may well be an underestimate. Handset prices have plummeted, and the smart phone is now an essential accoutrement of most youths, whether they are rich or poor; even in very remote rural areas, basic mobile phones are increasingly accessible to by young people. The use of smart phones performs phenomenal roles as far as teaching and learning are concerned.

Soyemi et al., 2015 however observed the cell phone can constitute a distraction leading to poor academic performance if it is not properly used. However, the capability of mobile phone to enhance learning far outweighs the disadvantages.

In addition, self-study can be achieved through self-paced e-learning or by taking the advantage of the cell phones using educational resources available, such as educational mobile apps. The incorporation of virtual Laboratory in a Mobile App will make learning in STEM easier and thus increase performance of students especially female students.

Development of gender responsive STEM curriculum

Gender-responsive STEM education includes transformation in teaching practices that are grounded in real life problems and lived experiences, while giving girls every opportunity to achieve at the highest level. To correct the anomaly of gender disparity in STEM will involve mainstreaming gender components into science education activities and teachers' pedagogical delivery (UNESCO, 2017).

There is need for gender responsive pedagogies that can accommodate the requirement, interest, and experience of students irrespective of their gender to create an enabling environment them to benefit maximally from science laboratory activities (Akhigbe and Adeyemi, 2020).

A paradigm shift from the traditional time-tested teacher-centered demonstration towards laboratory practices that provide students with opportunities to demonstrate and, visualize or verify information via the use of innovative technologies is recommended (Gambari, et al., 2017). The adoption of virtual laboratory in schools thus presents itself as an alternative to the traditional physical laboratory.

Mobile Applications

Mobile Application (M-apps) is also known as an app, is a type of application software designed to run on a mobile device such as a smart phone or Tablet computer. Currently, the most accessible electronic device in the world today is the mobile phone. Therefore, it can be deduced that majority of teachers and students possess this device. It is thus necessary for teachers to explore ways of utilizing mobile phones to enhance teaching and learning.

Mobile learning is quite new, studies have shown that it results in improved retention, decreases training times, and enhances productivity more than traditional training models. Improved retention happens when mobile learning is present as a standalone teaching method or as part of a blended learning program (Alhazmi and Rahman, 2012).

Unlike school, mobile applications can be available round the clock. Consequently, there is actually no reason to be concerned about schedules, because there can be a classroom anywhere. Mobile learning is not restricted by time; it is a relaxed form of learning. Most of the apps promote user-friendly control. Learners should only reach out for the device when they feel like learning. Young learners can operate it without much effort.

STATEMENT OF THE PROBLEM

Apathy towards Science and mathematics has been identified as responsible for the underrepresentation of Women and girls in STEM. The major cause of this limitation is because today's learners are still being taught the same traditional way their teachers were taught. Mansour & Salman (2011) points to the fact that one of the main reasons for reluctance of students to study mathematics is that the introduction and methods of teaching do not use modern technologies. The current educational systems in many African educational institutions involve the use of learning by memorization rather than support active exploration which is more attractive to students.

Students are more familiar with new online technologies than their teachers and they use them more often, teachers can leverage on this by coming onboard and embracing new technology solutions. There is the need to enhance the present curriculum delivery to attract female gender participation in science and technology-based courses for future growth and development (Soyemi and Soyemi, 2015).

Paradigms such as just-in-time learning, constructivism, student-centre learning and collaborative approaches have emerged and are being supported by technological advancements such as simulations and virtual reality.The focus of this study is to propose simple technology-supported learning environments in the STEM courses, blending it with the traditional face-to-face teaching for more female enrollment/performance.

Objective of study

The aim of study is to propose novel attracting and retaining strategies for STEM teachers and the use of mobile technology solutions such as Virtual Laboratory mobile App for enhancing female students' performance and enrolment into STEM programmes in Technical, Vocational Education and Training (TVET) Institutions.

Research Questions

1) What are the attracting strategies for increasing female students' enrolment in STEM education in TVET Institutions?
2) What are the retaining strategies for increasing female students' enrolment in STEM education in TVET Institutions?
3) What are the attitudes of STEM teachers towards combining the use of Virtual Laboratory Mobile Phone applications (VLMA) with existing learning systems to making STEM courses attractive to female students?

The null hypotheses were tested in the study:

1) Lecturers of STEM education will not differ strongly in their mean responses on attracting/retaining strategies for increasing female students' enrolment in STEM education in TVET Institutions based on their years of work experience;
2) Lecturers of STEM education will differ strongly in their mean responses on attracting/retaining strategies for increasing female students' enrolment in STEM education in TVET Institutions based on their years of work experience.

METHODOLOGY

Research design

The research design used for this study was descriptive survey which was conducted in TVET institutions drawn from selected African countries (Gambia, Malawi, Ghana, Nigeria and Kenya). Descriptive survey is defined as "any procedure in which data are systematically collected from a population or sample thereof through some form of direct solicitation like interview or questionnaire" (Igberaharha and Onyesom, 2021). Descriptive survey used in this study has been found to be the most applicable research design.

Population

The population of the study comprised 109 STEM teachers in Technical and vocational (TVET) Institutions across five countries (Kenya, Ghana, Malawi, Gambia and Nigeria) in Africa. The whole population is a manageable sample size and thus all participated in the study. The lecturers with different years of work experiences are all experts.

Instrumentation

The instrument to generate data was the modified form of questionnaire designed by Igberaharha and Onyesom, 2021. The modified questionnaire was sub-structured into four major sections. The section A generated respondents' demographic data while sections B, C and D contained 40 items bordering on the research questions, formatted on a "five-point rating scale of Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D) and Strongly Disagree (SD)." The data generated were subjected to one way analysis of variance (ANOVA). The entire respondents completed the questionnaire (100%) which was successfully retrieved and used for data analysis.

Method of data analysis

The data gathered for the study were analyzed statistically. The null hypotheses were tested at 0.05 level of significance using ANOVA. Decision on the research questions was based on a benchmark mean of 2.71 and 2.91respectively for attracting and retaining female students into STEM. This implies that "any item with a mean value of 2.71and 2.91 and above was regarded as agreed while any item with mean value of less than 2.71and 2.91 was regarded as disagreed". Furthermore, null hypothesis was accepted where the P-value is greater than 0.05 alpha level and rejected where the P-value is less than 0.05 alpha level.

Table 1: Demographics Data from Survey Results

1.	Sample Size	109	
2.	Number of Responses	109	
3.	Response Rate	100%	
4.	Gender	Male	36
		Female	73
5.	Country	Ghana	4
		Kenya	37
		Nigeria	26
		Gambia	8
		Malawi	33
6.	Highest qualification	Bachelor's Degree	41
		Master's Degree	28
		PhD 16	16
		Others	21
7.	Years of Work Experience	Less than 5 yrs	33
		Less than 10 yrs	19
		Less than 15 yrs	16
		Less than 20 yrs	9
		Greater than 20yrs	27

Table 1 shows that the response rate was 100% which means that results got in the study mirrors came from a complete response rate of the trainers. Most of the respondents are qualified with majority attaining PhD, Masters and Bachelor's degrees' level thereby giving professional responses.

RESULTS

The results presented in Table 2 - 5 answered research questions 1 and 2 respectively, while Table 6 and Table 6 show the results of hypotheses 1 and 2 respectively. Table 3 presents the results of respondents' ratings on the attracting strategies for increasing female students' enrolment in STEM education programme. The results indicated that all the items were rated above the mean benchmark point of 2.50. Thus, it implies that all the 18 were rated by the respondents as attracting strategies for increasing students' enrolment in STEM education. This is also confirmed by the grand mean which is above 2.50. The closeness of the standard deviation indicates the homogeneity of respondents' ratings.

Table 4 shows the respondents' ratings on the retaining strategies for increasing students' enrolment in STEM education. The results indicated that all the items were rated above the mean benchmark point of 2.50. Thus, it implies that all the 10 items listed on Table 4 were rated by the respondents as retaining strategies for increasing students' enrolment in STEM education. The proximity of the standard deviation values indicates the relatedness of respondents' ratings. The sufficiently large F values in Tables 6 and 7indicates that the model used in the study is significant

Test of hypotheses

Null hypotheses 1 and 2 formulated for the study were tested at 0.05 level of significance using analysis of variance (ANOVA) and their results are presented in Tables 6 and 7. Table 6 indicates that at 0.05 level of significance, 4 degrees of freedom numerator and 89 degrees of freedom denominator, the F-calculated value was 2.48 with a P-value of .2.71 which is greater than 0.05. Thus, the null hypothesis was therefore accepted. This implies that respondents did not differ strongly in the mean scores on the attracting strategies for increasing female students' enrolment in STEM education based on their years of work experience.

Table 7 indicates that at 0.05 level of significance, 4 degrees of freedom numerator and 54 degrees of freedom denominator, the F-calculated value was 2.557 with a P-value of 2.91 which is greater than 0.05. Thus, the null Hypothesis was therefore accepted. This implies that respondents did not differ strongly in the mean scores on the retaining strategies for female students' enrolment in STEM education based on their years of work experience.

TABLE 2: STRATEGIES FOR ATTRACTING FEMALES INTO STEM PROGRAMMES	
1	Conducting awareness campaigns
2	Debunking myths about STEM education
3	Highlighting job prospects of STEM education
4	Use of customized STEM education stickers
5	Use of customized STEM education t-shirts
6	Creating Facebook groups
7	Embracing twitter and other relevant social media
8	Designing STEM education promotional posters
9	Featuring STEM education talks on media
10	Creating interactive website for STEM education
11	Hosting events to showcase STEM education
12	Placing STEM education adverts on public and campus buses
13	Early intervention STEM education programmes in basic schools
14	Sensitization visits to secondary schools to give talks on STEM education
15	Organizing STEM education fairs
16	Networking with parents, counselors and advisors on STEM education
17	Redesigning STEM curriculum with flexibility
18	Using mobile Apps to make STEM subjects fun and engaging

TABLE 3: STRATEGIES FOR RETAINING FEMALES IN STEM PROGRAMMES	
1	Instituting regular orientations programmes for female students' in STEM

2	Cultivating active female students' participation in STEM organizations
3	Providing female students' in STEM with special opportunities
4	Managing female students' in STEM expectations
5	Strengthening female students' in STEM motivation and commitment
6	Maintaining efficient communication amongst female students' in STEM
7	Instituting regular interactions with STEM industrial experts
8	Sponsoring professional development activities for female students' in STEM
9	Providing mentorship programmes for female students' in STEM
10	Harnessing female students' in STEM motivation

Table 2 and 3 shows that all the items were rated above the mean benchmark point of 2.50. Thus, it implies that all the 18 were rated by the respondents as attracting strategies for increasing students' enrolment in STEM education programme and that all strategies for retaining females in STEM courses are important.

TABLE 4: SUMMARY OF STRATEGIES FOR ATTRACTING FEMALES INTO STEM EDUCATION

Groups	Count	Sum	Average	Variance
Strongly Agree	18	871	48.38889	219.8987
Agree	18	854	47.44444	96.73203
Neutral	18	146	8.111111	45.75163
Disagree	18	36	2	3.411765
Strongly Disagree	18	13	0.722222	0.565359

Table 4 indicates that almost half of the respondents Strongly Agreed (Average of 48.3) that all the strategies for attracting females to STEM are very important.

TABLE 5: SUMMARY OF STRATEGIES FOR RETAINING FEMALES IN STEM PROGRAMMES

Groups	Count	Sum	Average	Variance
Strongly Agree	11	580	52.72727	130.0182
Agree	11	499	45.36364	101.4545
Neutral	11	66	6	8.6
Disagree	11	11	1	0.8
Strongly Disagree	11	4	0.363636	0.454545

Table 5 indicates that majority of the respondents strongly (52.7) agreed and agreed (45.3) that strategies to retain females in STEM programmes is very important so that the female students can complete their courses. Only an average of 0.3 Strongly disagreed

TABLE 6: ANOVA OF MEAN SCORES FOR ATTRACTING FEMALES INTO STEM PROGRAMMES

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	42969.89	4	10742.47	146.6111	2.71E-37	2.479015
Within Groups	6228.111	85	73.2719			
Total	49198	89				

TABLE 7: ANOVA OF MEAN SCORES FOR RETAINING FEMALES IN STEM PROGRAMMES

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	29161.27	4	7290.318	151.0463	2.91E-27	2.557179
Within Groups	2413.273	50	48.26545			
Total	31574.55	54				

Table 8: Computed Scores and Decision Rules on the use of Digital Technology by STEM teachers based on Likert scale

Digital Technology	Strongly Agree 5	Agree 4	Neutral 3	Disagree 2	Strongly Disagree 1	Decision
Infusing digital tools into existing STEM curriculum can aid learning for girls	49/245	55/220	1/3	1/2	0	Strongly Agree
Use of digital technology can help girls to learn remotely	49/245	47/188	6/18	2/4	1	Strongly Agree
Application of digital literacy into STEM can help girls in learning	46/230	54/216	6/18	0/0	0	Strongly Agree
Access to internet connectivity can help make STEM education flexible for girls	61/305	39/156	5/15	1/2	0	Strongly Agree
Limited understanding of digital technologies restricts teachers' usage in teaching STEM	52/260	44/176	5/15	3/6	2	Strongly Agree
Using digital tools can help girls to solve socio-scientific problems such as climate change	35/175	60/240	12/26	1/2	0	Strongly Agree
I am proficient in the use of virtual science labs as a teaching tool	18/90	35/140	34/102	18/36	1	Strongly Agree
I can easily access online technology to teach	40/200	49/196	11/33	8/16	0	Strongly Agree
Teachers find it easy to use digital technology in teaching	15/75	36/144	33/99	20/40	1	Agree
The use of virtual science labs will aid teaching of STEM	33/165	52/208	17/51	4/8	0	Agree

Students in my school especially females can access online technology	16/80	45/180	30/90	13/26	2	Agree

TABLE 9: SUMMARY OF DIGITAL TECHNOLOGY SOLUTIONS

Groups	*Count*	*Sum*	*Average*	*Variance*
Strongly Agree	11	414	37.63636	248.0545
Agree	11	516	46.90909	65.29091
Neutral	11	160	14.54545	149.4727
Disagree	11	71	6.454545	53.07273
Strongly Disagree	11	7	0.636364	0.654545

Tables 8 and 9 indicates that majority of the respondents strongly (37.6) agreed and agreed (46.9) that digital technologies can enroll/ retain females in STEM programmes.

DISCUSSION OF FINDINGS

Respondents profiled in this study demonstrate that some simple strategies if implemented can add up to big gains in female student's performance, recruitment and retention in STEM. The data analysis result on Tables 2 and 4 pertaining to research question one revealed that attracting strategies are crucial initiatives needed to increase students'enrolment in STEM education. This is similar to the study by Igberaharha and Onyesom, 2021.

Prior studies have shown that public enlightenment, social media are effective strategies for attracting students to STEM education (Kimotho, 2019).

The test of the null hypothesis indicates that irrespective of the years of work experience of the respondents, their responses did not differ strongly on the attracting strategies for increasing students' enrolment in into STEM.

The results shown on Tables 3 and 5 relate to research question two and it indicate that all the retaining strategies examined in this study were important.

Again, the test of null hypothesis two indicated that despite the variations in the years of work experiences of the respondents, no strong difference was found. This implies that retaining strategies are also critical subventions that should be properly harnessed to enhance and sustain the enrolment of female students into STEM programme.

Table 8 is the weighted score of respondents on Likert scale that depicts the attitudes of STEM teachers towards combining the use of Virtual Laboratory Mobile Phone applications (VLMA) with existing learning systems to boosting the performance of female students in STEM courses. The teachers strongly agreed that infusing digital tools into existing STEM curriculum can aid learning for girls and access to internet connectivity can help make STEM education flexible for girls. They also strongly agreed that their limited understanding of digital technologies restricts their usage in teaching. This is in support of the study conducted by Alhazmi and Rahman, (2012). In addition, the respondents agreed that the use of virtual science laboratory will aid teaching/understanding of STEM courses and most of them are proficient in the use of virtual science labs as a teaching tool. The respondents also agreed that they and their students can easily access the internet.

CONCLUSION

This paper has clearly shown that there is the need to change the mode of curriculum delivery by infusing digital technology to foster female participation in STEM courses. A method of bridging the gap is by mainstreaming gender components into the pedagogical delivery as evident though the use of virtual Laboratory. Mobile App. Teaching and Learning has moved beyond the traditional method to more involving technological attractive methods that are more engaging. The statistical analysis from this study also supports the fact that female enrollment/retention in STEM will increase if the strategies were adopted.

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