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# **SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) RESOURCES AND NATIONAL DEVELOPMENT**

A KEYNOTE ADDRESS PRESENTED

BY

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*AT THE 4<sup>TH</sup> ANNUAL NATIONAL CONFERENCE OF THE SCHOOL OF  
SCIENCE, COLLEGE OF EDUCATION, AFAHA NSIT, AKWA IBOM STATE ON  
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Keywords: Education, resource, teacher, development, training, and assessment

## **PREAMBLE:**

In a conference of this magnitude it is expected that some in-depth analyses and discussions of resources associated with STEM Education as they enhance national development, be made in lead papers presentations and plenary sessions. What this keynote presentation will do is to uncover various resources of STEM Education and to show how they could be used for optimum development of nations. In doing this, we consider the concepts of the following concepts- Education, resources, teacher, development, training and assessment for a better articulation and integration of the subject involved. The concepts of Science, Technology, Engineering and Mathematics are assumed.

## **Education**

It is a common knowledge that Agriculture was the first profession man got involved in, judging from the story of the Garden of Eden in the Bible. But that was not before education. After man was created he was given some instructions (educated) on what to do generally and what to do specifically in the garden. The instruction was necessary because there was how God wanted man to be, behaviourally and responsibly. The only way to evoke this was through education. So, education started from the first day of human existence. The very first thing a new born baby does after coming out from the mother's womb is to cry. The cry is not necessarily announcing its arrival but it is to indicate a sharp change of

environment. From then the child begins to learn certain things to enable him/her adapt to the new environment. So, what is education?

#### A. Concept of Education:

Professionally, education is one of the concepts that cannot be fully articulated and comprehensively appropriated with a single definition. An Encyclopedia of Education defines it as *a form of learning in which the knowledge, skills and habits of a group of people are transferred from one generation to the next through teaching, training and research*. I consider this definition very useful because of the component parts embedded in it. Specifically, it provides the purpose of education to include acquisition of appropriate knowledge, skills and habits. Secondly, the definition also provides the means through which education can take place to include, teaching, training and research.

However, good as this definition seems, it could be necessary to ask the following questions:

- (i) Does every desirable learning result in education?
- (ii) Is it not possible to have learned something and yet not educated?
- (iii) Who is an educated man?

Analytically, an educated man is not only the person who has received learning in the knowledge, skills and habits but one who can:

(a). Function properly in the knowledge realm – the mind enlightened, intelligence sharpened and enhanced, and can think effectively and creatively.

(b). Apply skills acquired in solving specific problems of the society.

(c). Exhibit a positive habit; this has to do with societal values such as honesty, integrity, fairness, respect for elders and constituted authorities, etc.

It should be noted that these three-prong emphasis of the product of education is holistic. By implication, therefore anyone that scores even 2/3 of this cannot be said to be educated. One can therefore be certificated but not educated;

intelligent, brilliant in his/her profession or any human endeavour, yet not education. One can be learned but not educated.

Education exists in three basic types, namely: formal, informal and non-formal, as indicated by the Organization for Economic Co-operation and Development (OECD). While formal education emphasizes institutionalization of education with formal curriculum, disciplines and school system; the informal education is expected to occur under informal settings at home and in public gathering. Non-formal education occurs outside the formal school system. It takes place mostly under artisans such as carpenters, mechanics (radio, cars, and generators), hair dressers, tailors/seamstresses, ICT operators, etc. it should be emphasized that no form of education is dispensable. The current problem of unemployment in the country now could be associated with the overemphasis on formal education at the expense of other forms, especially the non-formal. The near total lack of emphasis on informal education has resulted in moral and social decadence in our society.

### **Resources:**

A resource, simply put, is something or someone capable of being used to actualize an aim. In this case there is a curriculum for each STEM disciplines and there are sets of aims associated with each. The aims, as usual are both in the long and short term ranges. On the short term range is the production of highly skilled, motivated and knowledgeable teachers of these disciplines who are capable of imparting upon the students and raising them up to be useful citizens for national development.

In between the curriculum and the aims and objectives exists a gap. No matter how excellent the curriculum is and how well articulated and achievable the aims are, without appropriate (sufficient and qualitative) resources, the realization of the aims will be utopic. This has been the key problem in our nation. We spend much more time on curriculum development than curriculum implementation, on the resources with which the aims could be achieved.

Resources in STEM Education include human, teaching materials, finances, services, infrastructure, and political goodwill, among others. Associated with the importance of resources <sup>are</sup> the resource production, resource allocation, resource

utilization and resource management. All these are very crucial in actualizing the aims and objectives of education and enhancing national development. Foremost among the resources needed in STEM Education is human resources- teaching and non-teaching. Of these two, teaching staff stands out. This is because whatever other resources are made available, unless a teacher utilizes it appropriately in teaching, is will be wasted.

Generally, the challenges with respect to resources in STEM Education have been that of:

- limited availability,
- limited utilization,
- limited supervision,
- limited development, and
- limited assessment.

### **National development**

Development can be seen as the process in which something goes through to reach its full capacity or potential. For example, a new born baby boy has all the features of an adult man, internal and external, but he cannot behave or function as an adult. The difference between the two is *development*. The baby will need to go through different stages of development to become mature. Hence development has to do with maturation and maturity. It should however be pointed out that there exist a difference between growth and development. With respect to the case the baby earlier mentioned, it is possible for the child to grow bigger and taller without a corresponding development in attitudes, values, intellect and temperament.

In the same way, there can be a national growth without nation development. In Nigeria, for instance, education, economy and politics have grown, but the index of development has been very low. There is much money, yet very many are living in abject poverty. In education sector, there has been growth in Student's' population, and the numbers graduates churned out every year, yet there has ~~not~~ been very little development, judging from the indices of national development.

National development is that which is aimed at building the various areas and segments of the nation specifically or generally. Measurement of national development includes the Gross Domestic Product (GDP), which has to do with the total value of goods and services produced in a country; Gross National Product (GNP), which has to do with income from foreign investments; Purchasing Power Parity (PPP), which takes into consideration local cost of living usually expressed as per capita income. Moreover, social indices such as quality of life, access to safe water, crime levels and rates, access to broadband internet connections, literacy level, corruption perception index, mortality rates, Human Development Index (HDI), life expectancy, adult literacy level, Human Poverty Index, among others. All these interactively determine national development.

### **Human resource production in STEM Education and National Development**

As earlier indicated the foremost resource in STEM Education is the teacher. The quantities as well as the quality of teacher available for these disciplines will therefore affect, directly and indirectly, national development. In the <sup>same</sup> vein, the ways teachers are produced definitely affect their quality. In our country today STEM Education teachers are produced through the following channels:

- ✓ a three-year programme at the College of Education
- ✓ a four-year programme at the Faculty of Education in the University
- ✓ a three-year degree programme in the University for holders of NCE
- ✓ Distance Learning programme of the NTI

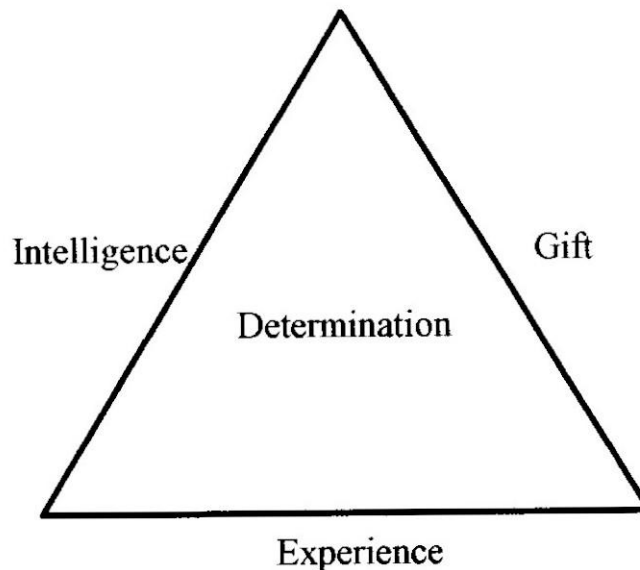
It is also to be noted that at all levels of teacher production in this country there are rooms for remedial programmes, unfortunately. It should equally be noted that what is happening in the various Teacher Education programmes is **Teacher Qualification, not Professional Teacher Training** (Onwioduokit, 2013). Many have gone through the teacher production programmes without becoming teachers. The abolition of Teacher Training Colleges (as they were called) is seen as an error that could be corrected. I wish this conference, at various plenary sessions address this issue. This is because the adage of “catching them young” is very fundamental in the proper production of teachers.



There is a need for a paradigm shift basically in the following areas:

- The stages of teacher production which should include an earlier training at the post primary level. This is without prejudice to the minimum qualification for teaching.
- The curriculum of teacher institutions. This should be done in such a way that the existing JSS and SSS curricula form integral parts of Teacher Education programmes at the Colleges of Educations and Universities respectively;
- Training and retraining that ensures hands-on involvement and participation;
- Abolition of remedial programmes in STEM Teacher Education; and
- Establishment of one -year internship period before graduation. This is to ensure enough on-the-job experience to teacher trainees.

It should be noted that effective teacher training has three major components, namely intelligence, gift and experience. While intelligence has do with the ability to gain and apply knowledge and skills, gift has to do with natural endowment and creativity. Experience on the other hand has to do with practical involvement in activities and events which culminate in acquisition of knowledge and skills. This can be represented with a triangle as shown below:



**Figure 1: Component Teacher Training**

## **Assessment of Teachers' productivity**

Assessment of teachers' performance has a way of imparting on teachers' morale, motivation and promotion. This is capable of imparting upon national development

Dissatisfaction is often expressed by parents and the society at large on the "fallen" standard of education. While a lot of people, including parents are being blamed for the ugly situation. It should be mentioned that the standard of education per se has not fallen. A cursory look at the recent curricula in schools shows improved quality learning experiences prescribed for learners. In terms of quality and depth of coverage, the present curricula are of higher academic standard than the previous ones. The problem is really with the output of education not necessarily with the standard. School leavers and graduates from institutions of higher learning are no longer capable of functioning at the level expected of them. In every system, be it mechanical or human; some basic things determine the quality of the output. These are the input and the channel involved. The two are mutually related and inseparable.

The expected input is made up of all learning experiences provided for by the curriculum as well as extra curricula activities under the auspices of the school. These experiences (input) are influenced by teacher's familiarity with the experiences and his ingenuity. In most cases, therefore, the actual input is less than the expected input. The actual input could also be regarded as the "teacher's output". In other words, teacher's knowledge of the subject matter and the use of appropriate instructional strategies, learning materials and assessment tools, his personal attitude to work and interest in student's progress, interactively determine the actual input.

On the other hand, the channel in educational system is the student. The intensity and quality of the output (Student's) depends not only on the actual input but also on the channel. Student's interest, readiness and willingness to learn cannot be overlooked. However considering the expected role of the teacher, it could be argued that even the channel (Student) is controlled by the teacher. A resourceful teacher can cause his student to be both interested and willing to learn. Therefore, to a very large extent, the actual output by the student, that is, student's performance depends on the actual input which is the teacher's output.



It is against such background that it could be reasonable to determine the teacher's efficiency based on student's performance. This can be expressed as follows:

$$\text{Teacher's efficiency} = \frac{\text{Actual Input}}{\text{Expected input}}$$

$$\text{This ratio is same as } \frac{\text{Actual output by student}}{\text{Expected output by student}}$$

This shows that Teacher's Efficiency is directly proportional to the actual output by the student. It is therefore not out of place to measure teacher's efficiency using student's performance.

### Using descriptive statistics to determine the efficiency of the teacher.

Descriptive statistics is of immense importance to both researchers in the field of education and classroom teachers. From the review of literature, a researcher can discover the trend of research studies on a particular problem, using the concept of the mode (Onwioduokit, 1977).

A classroom teacher who keeps weekly test scores records, for instance, could discover, through the use of a bar graph, the performance of the majority of students. All things being equal, the majority of students should have about an average score in the distribution. If this is not so, the distribution is said to be skewed. This can be positive or negative as shown graphically in Figure 1 below.

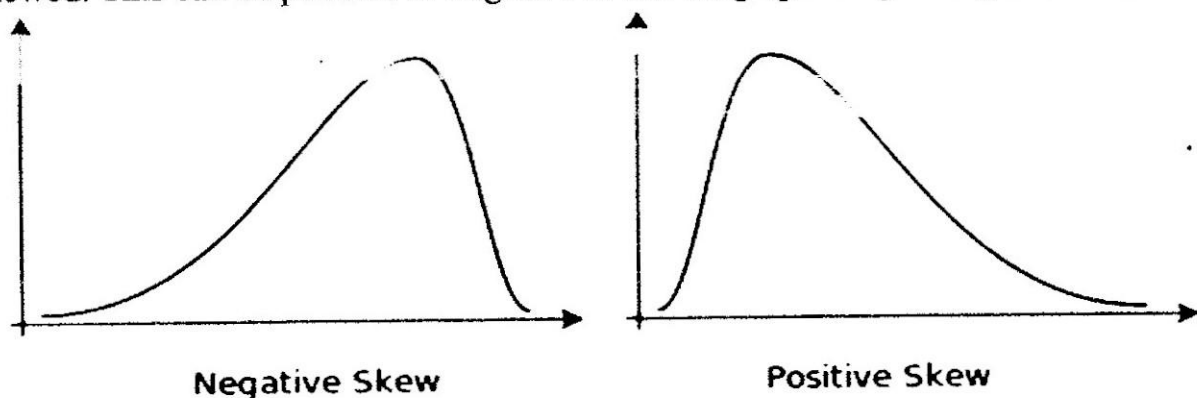


Figure 2: Skewness

Positive skewness implies that the performance of most students in a test is less than the mean performance of the class. This is generally a poor result.

Possible reasons include:

- i) The test may have been too difficult;
  - ii) The teacher may not have gotten students of low and average ability levels fully involved in the lesson. He may have only concentrated on those with high ability.
  - iii) Teaching may not have been done effectively
  - iv) Students may not have generally understood the lesson.
- On the other hand, negative skewness implies that most students perform above the class average.

Possible reasons include:

- i) The test may have been too simple for the students;
- ii) The lesson taught may have been well understood by the students;
- iii) Teaching may have been effectively done in terms of the use of appropriate teaching method, instructional materials, etc.

It is worthwhile to note that students' performance depends largely on their understanding of the lesson from which test items were drawn. Students' understanding in turn, to a great extent depends on the teacher and teacher-related factors.

In assessing the teacher's efficiency, the mean, median (or mode) and the standard deviation of the students' performance are required. While each of these could be used in isolation to show how efficient or otherwise a teacher is, the most reliable and best descriptive measure is obtained with the combination of all to give skewness. This is given mathematically as follows:

$$\text{Skewness} = \frac{3 (\text{mean}-\text{median})}{\text{Standard deviation.}}$$

For example, a skewness of say 0.64 suggests that 64% of the class obtained scores lower than the class mean. A decrease in positive skewness implies better performance and hence higher level of teacher's efficiency. An increase suggests the opposite. These deductions are reversed for negative skewness.

Judging from mean and standard deviation, the followings are deductible, given, for example, that three terminal results yielded, ( $\mu_1=58$ ), ( $\mu_2=65$ ), ( $\mu_3=68$ ) and the corresponding standard deviations of  $\beta_1 = 8$ ,  $\beta_2 = 5$  and  $\beta_3 = 3$ , respectively.

In this example, assuming the levels of difficulty of the tests is not significantly different; the increased mean performance indicates an improvement in the achievement of students and a corresponding improvement in the efficiency of the teacher. In a similar way, the decrease in the standard deviation (and also variance) from term to term indicates that the students' achievement becomes more homogenous each new term. This means that the gap between the high achievers and the low achievers is reduced from term to term so that the scores cluster more and more round the mean. Every teacher should aim at such results – increasing class mean and decreasing standard deviation. Absence of such trend suggests inefficiency on the part of the teacher.

### **Method:**

The study made use of tests performances of Senior Secondary two (SS2) students in the same school. Performances in three tests, each, in English, Mathematics and Biology were used. The rationale for using the same school and the same students was to control for school and student variables likely to adversely interact with the research setting. The three subjects were chosen because majority of the students in the chosen school offered the subjects.

A total of 23 (twenty-three) students had three tests scored in each of the three subjects considered. The performances of the students were analysed using mean, median, standard deviation and skewness index. These altogether were used to determine the most efficient of the three teachers.

## Result and Discussion:

From a case study of a school in Akwa Ibom State, the performance of students in three subjects are shown in Table 1

Table 1: Test Results of SS2 Students in English, Mathematics and Biology.

Maximum Score for each test = 30

S/NO	ENGLISH			MATHEMATICS			BIOLOGY		
	1	2	3	1	2	3	1	2	3
1.	9	8	7	3	2	8	5.0	5.0	5.0
2.	1	2	3	3	4	5	8.0	7.0	6.5
3.	5	7	5	4	7	0	7.0	6.5	7.0
4.	9	3	4	2	3	6	5.0	5.0	5.0
5.	8	2	1	6	3	7	5.3	6.5	6.0
6.	7	1	0	3	2	5	7.2	6.5	5.0
7.	4	2	4	3	7	6	7.0	6.0	6.5
8.	7	7	3	3	3	4	6.0	5.0	5.5
9.	8	4	1	6	6	7	6.0	6.0	5.0
10.	0	2	1	3	6	5	6.0	6.5	6.8
11.	8	9	7	3	1	0	5.0	5.0	5.0
12.	0	0	0	0	0	0	6.0	6.5	6.0
13.	0	1	0	6	1	0	7.0	6.5	6.0
14.	0	2	0	5	1	6	6.0	6.5	5.0
15.	6	9	7	3	6	9	6.9	5.7	6.0
16.	0	0	0	0	0	0	5.0	6.0	5.0
17.	8	2	7	4	1	5	6.8	7.1	6.0
18.	8	8	9	4	1	5	6.8	7.1	6.0
19.	8	5	5	2	3	4	7.7	5.7	6.0
20.	2	4	2	4	5	6	6.9	7.2	5.5
21.	8	3	0	6	7	0	5.0	5.0	5.0
22.	5	1	0	8	5	5	3.0	5.0	3.0
23.	3	9	0	4	8	8	6.0	6.2	5.8

Using the raw scores of students in the tests as shown in Table 1, mean, median, standard deviation and skewness were computed for each test and for each subject, as shown in Table 2.

Table 2: Mean, Median, Standard Deviation and Skewness of Students' Performance on English, Mathematics and Biology Tests.

Descriptive Measures	English			Mathematics			Biology		
	1	2	3	1	2	3	1	2	3
Mean, X	4.96	3.96	2.87	3.91	3.78	4.48	6.16	5.97	5.61
Median	06	03	02	4	3	5	6	6	5.8
Standard deviation	3.43	3.10	2.97	2.09	2.52	2.98	1.10	0.76	0.87
skewness	-0.91	0.93	0.88	-0.13	0.93	0.52	0.44	-0.12	-0.66

As shown in Table 2 above, judging from the mean performance of the students in each subject, it could be seen that the Mathematics teacher has the best performance best seconded by the Biology teacher. Although mean performances of English and Biology students decreased from term to term, and change is more pronounced in English than Biology.

Using standard deviation, the table shows that, students' scores in English clustered closer and closer with terms, applying a gradual bridging of the gap between the high and the low achievers. This was a complete opposite with respect to students' scores in Mathematics. In this case, the scores in the first test clustered most around the mean while those from the third test clustered least. This in general is a poor trend and does not show progress in the performance of the teacher. In biology the scores clustered more in the second test. The decrease in the standard deviation between first and second tests shows progress in the performance of the teacher. However, the value increased in the last test.

Using skewness as a comprehensive index of teachers' efficiency, Table 2 shows that the English teacher performed poorly between the first and the second test. At first 91% of the students have scores which were higher than the mean. But in the second test 93% of the students have scores below the mean even though the mean of the second test was lower than that of the first. This is a serious twist. The percentage was however reduced to 88% at the third test. A similar trend is seen

for Mathematics. The performance of the Mathematics teacher is almost as poor as that of the English teacher. The best performance is seen with Biology. At first test, 44% of the students have scores below the class mean performance. There was an improvement in the second test in that 12% of the students had scores above the mean. This improvement was however not maintained.

In order to get the index of efficiency of the teacher, it is necessary to find the mean of skewness for each subject. In doing this, only the skewness suggesting the percentage of students with performance above the class mean was used. In English therefore the mean skewness equals  $(0.91 + 0.07 + 0.12)/3$  which is 0.37. For Mathematics it is  $(0.13 + 0.07 + 0.48)/3$  which is 0.23.

Biology has the mean value of skewness as  $(0.56 + 0.12 + 0.66)/3$  which is 0.45.

From Table 2 therefore the indices of efficiency for English, Mathematics and Biology teachers in the case study are 0.37, 0.23 and 0.45, respectively. Biology teacher is therefore the most efficient of the three, based on the tests scores. He could therefore be rewarded or promoted based on his efficiency which suggests his productivity.

Biology teacher being most efficient here could result from the fact that students often consider Biology as being simpler than Mathematics or English. This depends more on attitude than facts. Attitude itself can be changed by a skillful teacher. However, attempting to determine the efficiency of a classroom teacher using descriptive statistics is not without some problems. The foremost include unequal distribution of learning materials, difference in difficulty indices of subjects and other environmental conditions. But it is worth noting that although the exercise could be cumbersome, it is useful.

### **Human resource management in STEM Education**

Another area that should be taken seriously with respect to the development of the nation is the STEM human resource supervision and management. This is with particular reference to the teacher. The rationale here is that most other STEM resources are either controlled directly or indirectly by the teacher. The need for proper supervision, monitoring and management of teachers is very crucial in the achievement of national development for the following reasons:



- ❖ If there must be discipline among learners ( pupils and students), teachers must be closely supervised and monitored with respect to their commitment to work, relationship with students and other staff, dress codes, punctuality work and stability at work.
- ❖ There is a significant relationship between discipline and performance (staff and students).
- ❖ Teachers are expected to be role models to students and should so be seen.
- ❖ Students' vices such as Examination misconducts can only sincerely curbed when teachers are committed to their in sincerity and truth. When students are properly taught to their understanding, appropriately motivated and shown good examples, they will most likely finish up as good and useful citizens capable of contributing to national development.

It is necessary to emphasize here that what the school system need is more of internal supervision. No external supervision can be as effective as internal. Head masters/mistresses, principals, their assistant as well of departments in schools and Colleges should be saddled with this responsibility be accordingly held accountable. Moreover, the need to restore boarding facilities in schools to enhance discipline and performance among students is long overdue.

As a matter of fact the National Teachers Institute (NTI) has over the years strives so much with respect to human resource in STEM Education and the effort is commendable. But it is worthwhile to say that the Institute should restrict itself to teachers retraining programmes such as seminars, workshops and short-term on-the-job training rather than undertaking full training programmes for certification.

## **Conclusion**

You will notice that I have concentrated on the human resources in STEM Education for national development. This focus is sequel to the importance of teachers in the teaching-learning process. The failure of teachers is the failure of not just school system but education itself. And we know that in any nation where education fails, the enter nation is bound to not only fail but collapse. It my expectation that lead presenters and other colleagues will take up specific areas of resources in STEM Education for detailed analyses.

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