INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Core Mathematics as a Predictor of Integrated Science Achievement of Students in the WASSCE Examination

Philip Dorsah
Tutor, Department of Science, Damongo Senior High School, Ghana
Sampson Mensah Akrosumah
Tutor, Department of Science, St. Ambrose College of Education, Ghana
Sampson Boye
Tutor, Department of Science, Atebebu College of Edeucation, Ghana

Abstract:
The purpose of the study was to determine whether students' achievement in integrated science could be predicted from their achievement in core mathematics. The study employed ex post facto design in which the 2017 West African Senior school Certificate Examination (WASSCE) results of 674 students of Damongo Senior high school comprising 430 males and 244 females was analyzed using the numerical values of their grades. Regression analysis and correlations were run with the students' core mathematics and integrated science grade values. The results showed a significant correlation between students' core mathematics grades and integrated science grades (r = .629, p = .000). Analysis of variance revealed a significant difference between core mathematics achievements and integrated science achievement [F (1, 672) = 440.609, p = .000]. The regression analysis gave a significant model fit (R^2 = .396, p = .000). This implied that 39.6% of the total variance in integrated science is accounted for by core mathematics. Also, independent samples t-test results revealed significant difference in achievement of males and females in core mathematics and integrated science.

Keywords: *Core mathematics, integrated science, achievement, predictor*

1. Introduction

Science and Mathematics education is an important tool for the development of any nation scientifically and technologically. The strength of any economy is based on skills that students obtain in math and science courses (Davis, Williams & Drake, 2017).

According to Opara, Chilee and Uchechi (2017),integrated science is a subject that covers all aspects of science as a unit. It is concerned with the teaching and learning of the fundamental units of science methods, processes, thoughts strategies and theories as a unitary body. Integrated science is a multidisciplinary course which provides a meaningful understanding of science without differentiating it into various scientific fields (Opara, Chilee & Uchechi, 2017).

Integrated science is an interdisciplinary science integrating concepts in all science disciplines such as chemistry, physics and biology. The justification for such an approach includes the fact that knowledge growth requires individuals to understand broader concepts that link science disciplines and the understanding that fragmentation of the curriculum reduces relevance and meaning to students (Bybee *et al*, 2008).

Despite that fact that integrated science is an activity-based subject that needs little of basic computation, but mostly of practical, it seems that the basic knowledge of Biology, Chemistry, Physics and Mathematics are the major criteria for full understanding of the subject. It is the measure of this parameter that determines the level of achievement of students in the subject (Ayodele, Adedayo & Ayeni ,2014).

1.1. Problem Statement

According to the ministry of Education as contained in the integrated science syllabus, Development in the current world is knowledge based on science and technology. For the country to develop faster, it is important for students to be trained in the processes of seeking answers to problems through scientific investigations and experimentation. Every citizen of the country needs training in science to be able to develop a scientific mind and a scientific culture. This is the only way by which people of the country could deal objectively with phenomena and other practical issues; prevent reliance on superstition for explaining the nature of things and help us to construct and build the present and the future on pragmatic scientific basis.(MoE, 2010). The integrated science syllabus is a conscious effort to raise the level of scientific literacy of all students and equip them with the relevant basic scientific knowledge needed for their own living and secondly, needed for making valuable contributions to production in the country.

According to Anamuah-Mensah, Asabere-Ameyaw, & Mereku, (2004), Ghana's average scores in Trends in International Mathematics and Science Study (TIMSS) in life science, chemistry and physics were the lowest of all the participating countries. Ghanaian students' performance in mathematics was far below that of all selected countries. The mean difference in performance between Ghanaian students and students in the highest performing country, Singapore in all content areas was about 300 scale points. Trends in International Mathematics and Science Study (TIMSS) is conducted by the International Association for the Evaluation of Educational Achievement (IEA), an international organization of national research institutions and governmental research agencies. The content domains covered at grade four are life science, physical science, and earth science. At grade eight, the content domains are biology, chemistry, physics, and earth science (Gonzales et al., 2008; Gonzales et al., 2004).

Despite the importance of the subject, poor performance of students in integrated science in the WASSCE has become a very serious issue of concern for educators and stakeholders of education in Ghana. The Poor performance of students in integrated science in Damongo Senior High School over the years necessitated this study. This poor performance may be attributed to many factors.

Research has revealed that there is a relationship between students' mathematics achievement and science achievement. Students' background and performance in core mathematics could be a factor in the poor performance in integrated science. Mathematics has an age-old relationship with physics, chemistry and other natural sciences. In other words, mathematics serves in many of the branches of science. This relationship is explained by Bell (1987) who viewed mathematics as the "Queen and Servant" of the sciences. Most investigators in the sciences are of the opinion that competence in mathematics is an essential part in the study of most courses in chemistry and physics. According to Ott (1993), linear relationship is the simplest pattern to describe concurrent changes between any two variables. Under this linear condition, variable relations can be summarized by a single correlation coefficient which substantially simplifies relevant interpretations of the research outcomes.

1.2. Purpose of the Study

The purpose of the study is to determine if there exist any relationship between core mathematics achievement and integrated science achievement in the West African Senior School Certificate Examination (WASSCE). And also, to determine the achievement of students in core mathematics and integrated science by gender.

1.3. Research Questions

- What is the relationship between core mathematics achievement and integrated science achievement?
- Is there any difference in the achievements of core mathematics and integrated science?
- Is the any difference in the achievement of males and females in core mathematics?
- Is there any difference in the achievement of males and females in integrated science?

1.4. Null Hypotheses

- $H_0$1: there is no relationship between core mathematics achievement and integrated science achievement.
- $H_0$2: there is no significant difference in the achievement of core mathematics and integrated science.
- $H_0$3: there is no difference in the achievement of males and females in core mathematics.
- $H_0$4: there is no difference in the achievement of males and females in integrated science.

2. Literature Review

Yeo Kee Jiar (2013) cited Chorin and Wright that mathematics is an intrinsic component of science and serves as a universal language and indispensable source of intellectual tools. Mathematics is widely regarded as the language of science and technology. Mathematics is the bedrock that provides the spring board for the growth of technology and the gate and key to sciences. Without mathematics, there is no science and without science there is no modern technology and without modern technology there is no modern society (Awodum & Ojo, 2013). Awodum and Ojo posit that mathematics is the precursor and the Queen of science and technology and the indispensable single element in modern societal development".

The close relationship between mathematics and science has long been recognized (Bholoa, Walshe & YRamma, (2017). Bholoa *et al* (2017) asserted that scientific inquiry cannot be feasible without quantifying findings using the language of mathematics, its notations, equations and procedures. According to Bholoa, Walshe and YRamma (2017), science and mathematics provide the means for interdependent ways of knowing the world, as both are concerned with identifying patterns and relationships. They added that Science provides contexts and applications for abstract mathematical principles, while mathematics provides the essential skills and processes necessary for science to make sense of the natural world. In recent times, the focus on STEM (science, technology, engineering and mathematics) education has led to growing interest in integrating all four of these subjects in various combinations in order to solve real life problems (Bholoa, Walshe & YRamma, (2017).

Mathematics and science often complement each other, with each building on skills taught by the other subject. Mathematics and science course taking during high school is associated with subsequent educational success (NSEP, 2018). Mathematics and science education have become focal areas in education policy in recent years, especially in the context of preparing students to be successful in STEM (science, technology, engineering, and mathematics) careers (Kuenzi 2008; Thomasian 2011 cited in NSEP, 2018).

Relations between mathematics and science education have been established in disciplinary roots of each subject. "Science provides rich contexts and concrete phenomena demonstrating mathematical patterns and relationships (Wang, 2005). According to Basista & Mathews cited in Wang (2005), mathematics provides the language and tools necessary for deeper analysis of science concepts and applications".

According to Aminu cited in Oyedeji (2011), the potential of a nation to develop in science and technology is a direct function of its adaptation in the area of mathematics. Hence the fact that mathematics is the corner stone of scientific and technological development cannot be over emphasized. Science generally uses mathematics as a tool to describe it concepts. According to Haveys cited in Oyedeji (2011), mathematics turns out to provide a useful tool for expressing scientific concepts. The implication of this is that some basic understanding of the nature of mathematics is requisite for scientific literacy. Hence it is imperative that for students to perform well in science, they need to perceive mathematics as part of the scientific endeavour, comprehend the nature of mathematical thinking and become familiar with key mathematical ideas and skills.

3. Methodology

A combination of correlational and ex post facto design was used in this study. According to Simon and Goes cited in Hinney and Nenty (2016), a combination of these designs facilitates a thorough investigation into the relationship and predictive nature of variables. The population consisted of 674 students who took the 2017 WASSCE examination. The data was extracted from WAEC results sheet data and then transfer into SPSS 22 for analysis. The grades of the students were transformed from discrete data into continuous data using numerical values of the grades through a secondary analysis. The real data involved in the analysis were the numerical values of students' grades. These values were subjected to the computer package on correlation statistic and regression analysis in order to answer the research questions.
Table 1 shows the grades, numerical values, score (percentage) and interpretations of the WAEC grading system used. Independent sample t-test, correlation, linear regressions and analysis of variance were used to analyze the data. The null hypotheses were tested at the .05 significance level

Grade	Numerical Value	Score (%)	Interpretation
A1	1	80-100	Excellent
B2	2	70-79	Very Good
B3	3	65-69	Good
C4	4	60-64	Credit
C5	5	55-59	Credit
C6	6	50-54	Credit
D7	7	45-49	Pass
E8	8	40-44	Pass
F9	9	0-39	Fail

Table 1: WAEC Grading System

4. Results and Discussion

4.1. Research Question 1: Relationship between Core Mathematics and Integrated Science Achievements

4.1.1. Correlations Analysis

The results showed that there is a positive significant correlation between mathematics achievement and integrated science achievement (r = .629, *p* = .000). Therefore, we fail to accept the null hypothesis.

Integrated Science		
Pearson's r	Core mathematics	.629
Sig (1 tailed)	Core mathematics	.000
N	Core mathematics	674

Table 2: Results of Bivariate Correlations

This is consistent with that of Li, Shavelson, Kupermintz and Ruiz-Primo (2002). They analysed TIMSS data in the United States and found that the correlations between mathematics and science total scores was high (r = .78). Correlations were also high between mathematics and science for both boys and girls.

4.2. Regression Analysis

Linear regression analysis was run with integrated science achievement as dependent variable and core mathematics achievement as predictor variable. The results are presented in Table 3 and Table 4.

Model	R	R^2	Adjusted R^2	Std. Error of The Estimate	Change Statistics				
					R Square Change	F Change	df 1	df2	Sig. F Change
1	.629[a]	.396	.395	1.265	.396	440.609	1	672	.000

Table 3: Results and Model Summary of regression analysis
a. Predictors: (Constant), Core Mathematics Score

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.005	.371		.015	.988
	Core mathematics score	.937	.045	.629	20.991	.000

Table 4: Model Coefficients of Regression Analysis
a. Dependent Variable: Science Score

The results reveal a significant fit of the overall model, F (1, 672) = 440.609, *p* =.000, with a co-efficient of determination, R^2 of .396 and standard error of .045. This implies that 39.6% of variance in integrated science achievement is accounted for by the predictor (core mathematics). Also, 60.4% of variation in integrated science achievement cannot be explained by their performance in core mathematics. Hence the regression model is represented as:

Y = .005 + .629 X + .045
Y = integrated science achievement.
X = Core mathematics achievement.

4.3. Research Question 2: Achievements in Core Mathematics and Integrated Science

The results of the ANOVA showed that there is significant difference in the achievement of students in core mathematics (*M* = 8.24, *SD* = 1.093) and integrated science (*M* = 7.72, *SD* = 1.626), [F (1, 672) = 440.609, *p* = .000]. This implies that students performed better in integrated science than in core mathematics. The mean scores imply that on the average, students more likely scored between a D7 and E8 in integrated science and between E8 and F9 in core mathematics. Therefore, we fail to accept the null hypothesis.

	Mean	SD	N
Integrated science score	7.72	1.626	674
Core mathematics score	8.24	1.093	674

Table 5: Descriptive Statistics of ANOVA

Model		Sum of Squares	df	Mean Square	*F*	Sig.
1	Regression	704.906	1	704.906	440.609	.000b
	Residual	1075.095	672	1.600		
	Total	1780.001	673			

Table 6: Analysis of Variance (ANOVA) Results
a. Dependent Variable: Integrated Science Score
b. Predictors: (Constant), Core Mathematics Score

4.4. Research Questions 3 and 4: Core Mathematics and Integrated Science Achievements by Gender

Independent samples t-test was performed to find out if there is any difference in core mathematics achievement between male and female students. The results revealed that there is significant difference in achievement of male students (*M* = 8.14, *SD* = 1.185) and female students (*M* = 8.41, *SD* = .882) in core mathematics [*t* (672) = -3.133, *p* = .002]. Therefore, we fail to accept the null hypotheses. Also, the results showed a significant difference in the achievement of male students (*M* = 7.43, *SD* = 1.768) and female students (*M* = 8.23, *SD* = 1.181) in integrated science [*t* (672) = -3.393, *p* = .001]. Therefore, we fail to accept the null hypotheses. In both subjects, males performed better than females.

Subject	Group	N	M	SD	*t*	*p*
Core mathematics	Male	430	8.14	1.185	-3.133	.002**
	Female	244	8.41	.882		
Integrated science	Male	430	7.43	1.768	-3.393	.001**
	Female	244	8.23	1.181		

Table 7: Independent Samples t-test Results
*** Significant, p < .05*

The results are consistent with others for example, Anamuah-Mensah, Asabere-Ameyaw, & Mereku, (2004), reported that the overall performance of boys (with an overall mean of 271) was significantly higher than girls (with overall mean of 236) in science in TIMSS 2003. They also found that the overall performance in mathematics indicated that boys (with a mean of 283) significantly outperformed girls (with a mean of 266) by 17 scale points. In four of the five content areas, that is, Number, Algebra, Geometry and Data, Ghanaian male students performed significantly better than their female counterparty (Anamuah-Mensah *et al*.2004).

Li, Shavelson, Kupermintz and Ruiz-Primo (2002) also analyzed TIMSS data in the United States. They found that in mathematics boys performed statistically better than girls in fractions (effect size = .12) and measurements (effect size

= .12), although the difference was too small. In science they found that boys performed better than girls in earth science (effect size = .22), physics (effect size = .26), and chemistry (effect size = .27).

However, TIMSS 2007 results showed that males performed significantly higher than female classmates overall in science, scoring higher in three of the four sciences content domains: biology, chemistry, physics, and earth science. According to Amelink (2009), United States males and female students showed no measurable difference in their average science performance in Trends in International Mathematics and Science Study (TIMSS, 2007). While differences were not significant, examining performance by content areas shows males outperformed in one content area: earth science (536 v. 531). There was no measurable difference detected in the average scores by gender in either the life science or physical science domains.

There was no measurable difference detected in the average science scores of U.S. eighth-grade males and females in the chemistry domain. Again, among U.S. eighth-graders trends reveal continued higher performance in science by males in certain content areas (Amelink, 2009). In 2003, males outperformed females in science, which was also the case in TIMSS 1999 and 1995 (Gonzales *et al*., 2004).

Kabote, Niboye, and Nombo (2014),found that girls' performance was higher than boys in some periods in mathematics and science. Zarrett, and Eccles cited in Larson, Stephen, Bonitz and Wu (2014), based on a large sample in the United States, provided evidence that girls had higher science grades than boys in grades 1 through 12.
According to Larson *et al.* (2014) the evidence for gender differences in science achievement appears to be inconclusive.

5. Conclusion

The findings of this study revealed that there is a relationship between mathematics and integrated science and the correlation is quite high. Again, male students performed higher than females in mathematics and science.
The findings imply that performance in core mathematics can be to some extent used to predict performance in integrated science.

The implication of the results of the study is that the study of mathematics should receive greater attention in senior high schools in Ghana.

Research has sought to identify plausible explanations for differences in science achievement between males and females. Mathematics preparation may influence science achievement. While females have made considerable gains in science achievement, mathematics skills may still be lacking thereby influencing performance in science-related majors (Clewell & Campbell, 2002; Trenor, 2007).

Among undergraduates, stereotypes may exist that science is a male dominated field, which is further reinforced by lack of role models in STEM disciplines, affecting persistence. Females are likely to find fewer peer, faculty, and established scientists who are also female, leading to feelings of isolation during their educational experience (Clewell & Campbell, 2002; Trenor, 2007). Perceptions may also impact the interest of females in STEM related careers. Females who anticipated a career to be male-dominated, which could increase the likelihood of occurrences of sexist behavior, had less interest in those fields (Gharibyan, 2007).

6. References

i. Amelink, C. (2009). Literature Overview: Gender Differences in Science Achievement. SWE-AWE-CASEE ARP Resources-Gender Differences in Science Performance. SWE-AWE CASEE Overviews. Retrieved On 8/9/2018 from http://www.AWEonline.org.
ii. Anamuah-Mensah, J., Asabere-Ameyaw, A., & Mereku, K.D. (2004). Ghanaian Junior Secondary School Students' Achievement in Mathematics and Science Results from Ghana's participation in the 2003 Trends in International Mathematics and Science Study (TIMSS), Ministry of Education, Youth and Sports, Accra, Ghana.
iii. Awodun, A., O., & OJo, O., A. (2013). Mathematics Skills as Predictors of Physics Students' Performance in Senior Secondary Schools. International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064. Volume 2 Issue 7, July 2013 www.ijsr.net.
iv. Ayodele M.O., Adedayo J.O. & Ayeni M.F. (2014). Predictive Power of Selected Variables on Students' Academic Achievement in Integrated Science. Greener Journal of Educational Research Vol. 4 (3), pp. 085-090, May 2014. ISSN: 2276-7789
v. Bell, E. T. (1987). Mathematics, queen and servant of science. Washington DC. The
vi. Bholoa, A., Walshe, G., YRamma, Y. (2017). Curriculum Implications of the Integration of Mathematics into Science. K. S. Taber & B. Akpan (Eds.), Science Education, 211–220, 2017 Sense Publishers. https://link.springer.com/chapter/10.1007%2F978-94-6300-749-8_16
vii. Clewell, B. C., & Campbell, P. B. (2002). Taking Stock: Where We've Been, Where We Are, Where We're Going. Retrieved August 10, 2008, from http://www.urban.org/url.cfm?ID=1000779
viii. Davis, C. A., Williams, Q.L., Drake, C.T. (2017). Mathematics Ability and Science Reasoning as Predictors of Science Achievement among African American Students at a Historical Black College or University. Journal of Mathematical Sciences & Mathematics Education Vol. 5 No. 2
ix. Gharibyan, H. (2007). Gender Gap in Computer Science: Studying its Absence in One Former Soviet Republic. ASEE 2007 Proceedings: 2007 Annual Conference. Retrieved March 1, 2009, from http://soa.asee.org/paper/conference/paperpaperview.cfm?id=4013
x. Gonzales, P., Guzmán, J. C., Partelow, L., Pahlke, E., Jocelyn, L., Kastberg, D., et al. (2004). Highlights from the Trends in International Mathematics and Science Study (TIMSS) 2003 (NCES 2005–005). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

- xi. Gonzales, P., Williams, T., Jocelyn, L., Roey, S. Kastberg, D., & Brenwald, S. (2008). Highlights from the Trends in International Mathematics and Science Study (TIMSS) 2007. U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.
- xii. Hinneh, J. T. & Nenty, H. J. (2016). Analysis of the Predictive Validity of Students' Performance in Core Sciences on Liberian SHSCE with WASSCE as the Criterion. IOSR Journal of Research & Method in Education (IOSR-JRME) e-ISSN: 2320–7388,p-ISSN: 2320–737X Volume 6, Issue 4 Ver. IV (Jul. - Aug. 2016), PP 25-31. www.iosrjournals.org
- xiii. Kabote, S.J., Niboye, E.P., Nombo, C.I. (2014). Performance in Mathematics and Science Subjects: A Gender Perspective for Selected Primary Schools in Rural and Urban Tanzania. International Journal of Gender and Women's Studies September 2014, Vol. 2, No. 3, pp. 87-105 ISSN: 2333-6021 (Print), 2333-603X (Online). DOI: 10.15640/ijgws.v2n3a6.URL: http://dx.doi.org/10.15640/ijgws.v2n3a6
- xiv. Larson, L. M., Stephen, A., Bonitz, V. S., & Wu, T. (2014). Predicting science achievement in India: Role of gender, self-efficacy, interests, and effort. Journal of Career Assessment, 22(1), 89-101.
- xv. Li, M., Shavelson, R.J., Kupermintz, H. Ruiz-Primo, M. A. (2002). D.F Robitaile and A.E Beaton (eds), Secondary analysis of the TIMSS Data, 233-249, Kluwer Academic Publishers. On the relationship between mathematics and science in the United States. Mathematical Association of America
- xvi. Ministry of Education (MoE) (2010). *Teaching Syllabus for Integrated Science (SHS)* Curriculum Research and Development Division (CRDD), Accra, Ghana. September, 2010.
- xvii. NSEP (2018). Paths through Mathematics and Science Patterns and Relationships in High School Coursetaking. NCES 2018-118. U.S. Department of Education.
- xviii. Opara,D., Chilee,I.M., Uchechi, S.(2017). Basic Science Junior School Certificate Examination As Predictor Of Senior School Certificate Examination In Physics, Chemistry And Biology In Aba Metropolis Of Abia State Nigeria. IOSR Journal of Research & Method in Education (IOSR-JRME), Volume 7, Issue 6 Ver. II (Nov. – Dec. 2017), PP 32-38. E-ISSN: 2320–7388,p-ISSN: 2320–737X. www.iosrjournals.org.
- xix. Ott, R. (1993). An introduction to statistical methods and data analysis (4th ed.). Belmont, CA: Duxbury.
- xx. Oyedeji, S.O. (2011). Mathematics Skills as Predictors of Science Achievement in Junior Secondary Schools. World J Young Researchers 2011;1 1((4 4))):60 ISSN 2249-0566, 2011.
- xxi. Trenor, J. M. (2007). The Women-In-Engineering Pipeline. Retrieved August 7, 2008, from:http://www.eweek.org/site/News/Eweek/2007_marathon/Trenor.ppt#258,7,The%20women-in-engineering%20pipeline
- xxii. Wang, J. (2005). Relationship between Mathematics and Science Achievement at the 8th Grade. International Online J Science Math Ed vol 5 pp 1-17, April, 2005.
- xxiii. Yeo Kee Jiar (2013) "Mathematics Thinking and Physics achievement of Secondary school students". . 2013. Online. Retrieved on 4/05/2013. 394