

A Correlation Study of Mathematics and Science Subjects Achievements in Secondary Schools

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Abstract: Mathematics is a subject that is widely applied in solving science problems. There has been an argument that to perform well in sciences, one must also perform well in mathematics. In the light of this assertion, this paper studied the correlation between mathematics and science subjects' achievements in secondary schools. Two science subjects, physics and chemistry were considered. The study used certificate of secondary education examination results for basic mathematics, physics and chemistry subjects of 229 students from three secondary schools located in Arusha, Tanzania. The schools were chosen based on performance ranks, high performing school, medium performing school and relatively low performing school. The results were for the year 2020. The grades were coded using the scale A – 1, B – 2, C – 3, D – 4, and F – 5. Scatter diagrams and correlation analysis approaches were used to arrive at the conclusion. The study found that there is a moderate positive relationship between mathematics achievements and physics achievements in least performing schools, meaning that students with good performance in mathematics are expected to perform better in physics. On the other hand, the study found a weak positive relationship between mathematics achievements and physics and chemistry achievements in high performing school. The study proposes that performance in mathematics should not be a criterion for selecting students to study science subjects. The results may be useful to educators responsible for selecting students for further studies in science subjects.

Keywords: Correlation Analysis, Correlation Coefficient, Coded Grade, Mathematics, Physics, Chemistry

1. Introduction

Mathematics is one of the most useful and fascinating divisions of human knowledge. Mathematics underpins science, technology, engineering, and itself as a discipline [5]. Apart from its concepts and skills, its application in everyday life situations, mathematics has an important role in many other areas of science and technology. According to Wilson and Nakakoji, mathematics is foundational to science and engineering and the best approach to mathematics is to understand it as a language for describing physical and chemical laws. Mathematics has all three approaches to science, observation and experiment, theory, and modelling require mathematical concepts and skills [12]. Mathematics and sciences are subjects taught in different levels of education systems around the world. There are many areas

where mathematics and sciences overlap and as more areas of science and engineering develop, they become indistinguishable from some areas of mathematics. Among the courses taught in most schools, physics is a subject heavily dependent on mathematical skills [1, 2, 6, 11]. However, the demand on mathematical preparation is not as strong in biology and some other sciences, [14].

This study focused on the relationship between achievement in mathematics and sciences in secondary schools and whether achievement in mathematics subject stir up achievement in science subjects. Many researchers and authors undoubted agree on the relationship between mathematics and sciences. [8] researched on factors affecting mathematics and science achievement. The findings showed that one variable affecting the achievement of both subjects is problem solving skills. This variable can lead to science achievement being affected by mathematics achievement and

vice-versa. Butts [4] argued that mathematics and science have a symbiotic relationship and that adopting a cross circular approach to teaching both subjects in primary schools creates a perfect combination. Frykholm & Meyer, [1, 6], on the relationship between mathematics and science, concluded that mathematics teachers can avoid science while teaching mathematics but science teachers are inflexible to avoid mathematics when teaching science. Kaptan and Timurlenk [8] argue that science depends on mathematics although there has been little research work specifically linking science and mathematics. Some studies have suggested that the performance of science subjects is adversely affected by other subjects including mathematics and that good performance of mathematics improves the performance of science subjects. It is clear that there are common variables that can affect achievement of both subjects, however knowledge and skills of one subject can be used to study the other subject [3, 15, 17, 18]. This study therefore explores whether achievement in mathematics contributes to achievement in science. In particular, the study focusses on achievement in basic mathematics and achievement in science subjects, namely, Physics, Chemistry and Biology that are taught in secondary schools [7]. In Tanzania, certificates of secondary education examination performance items response analysis show that in 2018, 20.02% of candidates who sat for basic mathematics examination passed the examination. 45.5% of candidates who sat for Physics examination passed, 62.17% of candidates who sat for Chemistry examination passed and 73.3% of candidates who sat for Biology passed the examination [13]. The results indicate better performance in the sciences. It is not clear whether the better performance in science is partly contributed performance in mathematics.

2. Statement of the Problem

Physics is a discipline taught in secondary schools and higher levels that heavily make use of mathematics in solving its problems. Chemistry, another science subject has some areas that require the knowledge and skills of mathematics. Biomathematics is specially application of statistical techniques in analyzing data with biological background. The three science subjects require mathematics. Basic mathematics has been made core and compulsory especially for science students in secondary schools while the sciences at some levels is optional. The performance of sciences is affected by many variables, including mathematical abilities since mathematics is necessary for sciences. Based on this assertion, this study explored whether achievement in mathematics has any relationship with achievement in sciences in Tanzanian secondary schools so that teachers and other stakeholders can see how best to carry out the teaching of these disciplines. Therefore, as its objectives, the study assessed the relationship between performance in mathematics and performance in physics and chemistry separately in certificate of secondary education examination. The study did not consider the cause-and-effect relationships.

3. Review of the Literature

Science subjects explain the existence and occurrence of phenomena while mathematics serves as a tool for analysis and synthesis of the phenomena, furthermore, mathematics is essential to finding solutions to questions about the natural world in scientific inquiry [2]. Therefore, knowing the relationship between mathematics and science in schools is vital during the teaching and learning of these two disciplines. Different researchers have enquired about this relationship from different angles with different objectives. Wang [17], used students test scores to examine the relationship between mathematics and science achievement and observed a moderate correlation coefficient. The objective of the study, among others, was to assess the relationship between these two disciplines in TIMSS/TIMSS-R countries. A similar study was done to assess relationship between mathematics grades and the academic performance of accounting students at Al-Zaytoonah University of Jordan. The findings of this study showed that mathematics grades have a significant positive effect on the academic performance of accounting students [16]. These findings suggest that improved teaching in mathematics will lead to better grades that in turn may cause better performance in accounting. Another study is that of Elango [19] who studied the role played by mathematics in biology. The findings of the study revealed that there are areas of biology which have advanced because of application of mathematics especially mathematical modeling. The idea here is that the knowledge of mathematics can simplify learning of other science disciplines. A learner who masters mathematics is therefore likely to master science subjects. Kiray [9] conducted a study to determine the order of significance of the factors influencing achievement levels in science and mathematics courses using data from three distinct international examinations. According to this study, the findings are that achievement or underachievement in mathematics and science course affect each other and achievement in mathematics has more effect in accounting for the achievement in science than the other way round. The findings of this study give evidence of the existing relationship between mathematics and science subjects.

In summary, various researches about the relationship between mathematics and science subjects have been done with different intentions. Some studies were trying to establish dependence nature of the two disciplines, other studies were trying to establish on how achievement in one discipline accounts for the achievement of the other under different situations.

4. Methodology

Correlation research design was used to investigate relationship between performance of mathematics and science subjects in certificate of secondary education examinations. The approach was chosen because no intervention or manipulation of data was done. The science subjects considered are physics and chemistry. The study

used secondary data approach to collect data – grade results of certificate of secondary education examination for the year 2020 in mathematics, physics and chemistry from the official website of the national examinations council of Tanzania. The results were collected from Arusha, Precious Blood and Arusha day secondary schools. The schools were chosen based on their performance. For the year 2020, Arusha secondary school is ranked 958, Arusha day secondary school is ranked 575, and Precious Blood secondary school is ranked 15 nationally. The grades were then coded using the scale A – 1, B – 2, C – 3, D – 4, and F – 5. The coded values were then used to compute the correlation coefficient. The study considered bivariate statistical correlation between mathematics and the other two science subjects. The correlation coefficient, r , of the relationship were calculated by using the formula

$$r = \frac{N \sum XY - \sum X \sum Y}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}}$$

Where X and Y are the coded grade scores and N represent the number of students who sat for the examinations in each

school. The choice of the coefficient was done from the fact that it gives both the direction and magnitude of the relationship. The significance of the correlation coefficient is tested by calculation the p-value [10].

5. Findings and Discussion

This section represents the findings and discussion.

The study collected 229 result grades from three schools. The grades were then coded using the scale A=1, B=2, C=3, D=4, and F=5. The numerical values corresponding to the same student in three subjects – mathematics, physics, and chemistry were then analyzed to establish the findings.

The study first examined the association trends by means of scatter plots. For each school, a scatter plot of mathematics and physics, and mathematics and chemistry were constructed. Figure 1 are the scatterplots of school A with 84 students between mathematics and physics and mathematics and chemistry.

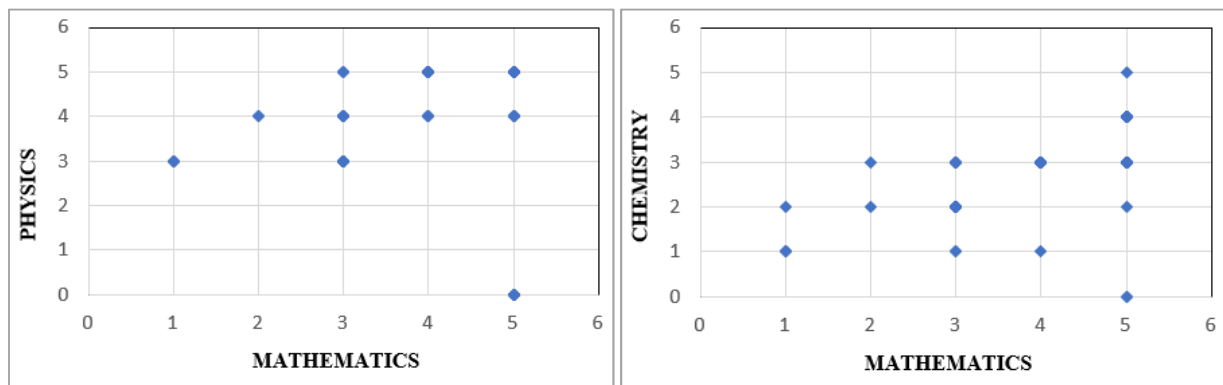


Figure 1. Scatter Plots of Mathematics and Science Subjects Performances in School A.

Figure 2 are the scatter plots of 61 scores from the school B, and figure 3 depicts the scatter plots of 84 grades from school C. In each case, mathematics is plotted against the two science subjects.

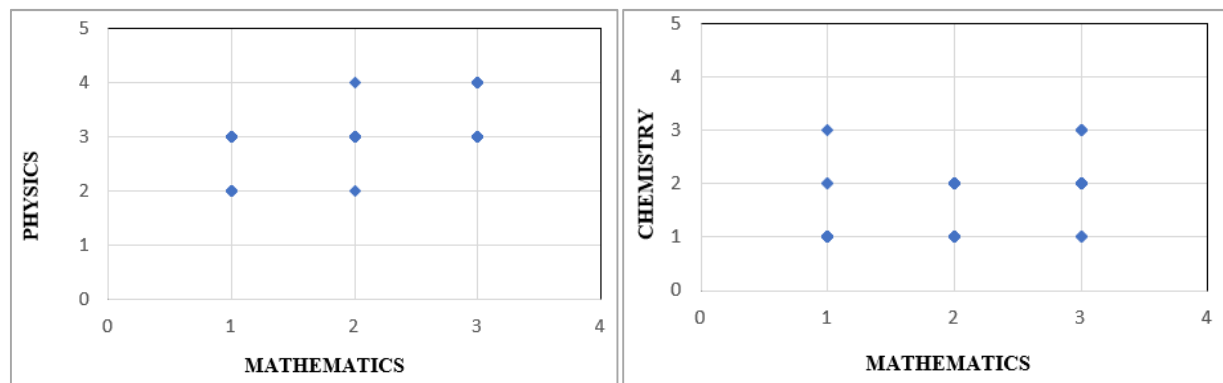


Figure 2. Scatter Plots of Mathematics and Science Subjects Performances in School B.

Observing the scatter plots tell us that mathematics grades are generally better than physics grades. There is also a positive association that can be observed between mathematics grades and physics grades. The linear trend is well above the horizontal

axis exhibiting the better grades in mathematics.

On the other hand, figure 1 shows that mathematics grades and chemistry grades do not exhibit an obvious trend except in school C. This is supported by the fact that some good

grades in mathematics corresponds to slightly lower grades in chemistry and viceversa. However, a number of lower grades

in mathematics corresponds to lower grades in chemistry (figure 1 and figure 3).

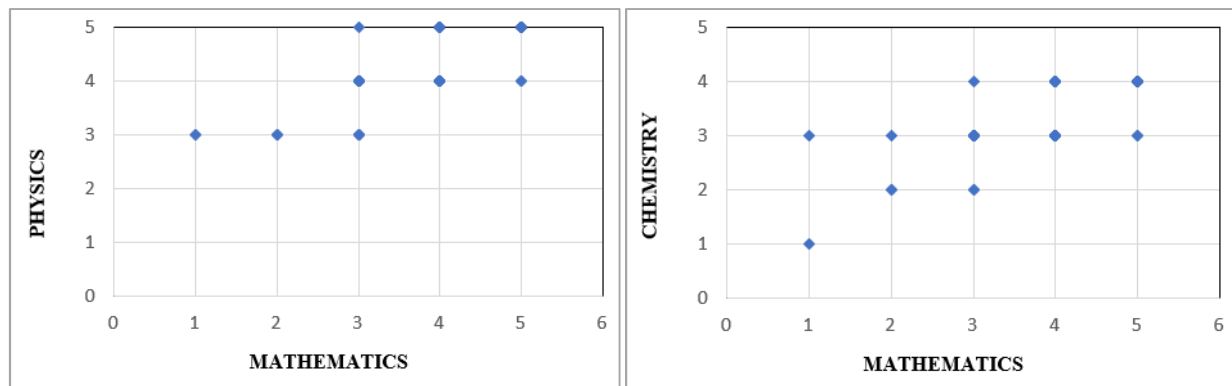


Figure 3. Scatter Plots of Mathematics and Science Subjects Performances in School C.

To establish further the existence of relationship between mathematics grades and physics and mathematics and chemistry grades, correlation coefficients were calculated for each pair of mathematics grades and physics grades as well as mathematics and chemistry in each school. Table 1 shows the computed correlation coefficient.

Table 1. Correlation Coefficient.

	SCHOOL A		SCHOOL B		SCHOOL C	
	M & P	M & C	M & P	M & C	M & P	M & C
N	84	84	61	61	84	84
r	0.7333	0.7238	0.5301	0.5375	0.7321	0.7022

The computed correlation coefficient for mathematics grades and physics grades in two schools have a value above 0.7 which is a moderate linear association. But in one school, the coefficient is 0.53 which is somewhat weak. For mathematics grades and chemistry grades, the computed correlation coefficient is 0.73, 0.70, and 0.53. Here it is again, two moderate association and one weak association.

P-value was computed to check if the correlation coefficient computed is statistically significant with an alpha level of 5%. Table 2 shows the p-value obtained.

Table 2. Correlation Coefficient Probability.

	SCHOOL A		SCHOOL B		SCHOOL C	
	M & P	M & C	M & P	M & C	M & P	M & C
P-Value	0.00001	0.00001	0.000011	0.00001	0.00001	0.00001

The p-values computed, in all cases, are less than the accepted value of 0.05, hence the correlation coefficients computed are statistically significant.

6. Conclusion

The following are the findings of this study in relation to the objectives:

- 1) The scatterplots and the small computed p-value suggest that there is a relationship between mathematics achievements and physics or chemistry achievements. Therefore, the computed correlation coefficient is

statistically significant.

- 2) Achievements in mathematics have a moderate positive linear relationship with achievements in physics. This follows from the correlation coefficients of over 0.7 in two least ranked schools. This suggest that, students who are doing better in mathematics can do better in physics and vice versa, if they study both subjects in these schools. The same applies to the relationship between mathematics and chemistry.
- 3) The relationship between mathematics achievements and both physics and chemistry achievements are weak positive linear relationship in high ranked school. This is suggesting that a student who has performed well in mathematics may or may not perform well in chemistry.

Therefore, the study recommends that performance or pass in mathematics should not be taken as a condition for students who will continue studying science subjects as is the case with many advanced level secondary schools and institution of higher learning in Tanzania. It is evident from this study that, a student may perform well in chemistry regardless of the mathematics performance.

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