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THE RELATIONSHIP BETWEEN STUDENTS' ACHIEVEMENTS IN MATHEMATICS AND THEIR PERFORMANCE IN ECONOMICS

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Abstract

The study, conducted in selected senior high schools in the Sekondi-Takoradi Metropolis of Ghana sought to investigate the relationship between students' achievements in Mathematics and their performance in Economics. A questionnaire which contained a Test of Economics Understanding (TEU) as well as a Test of Mathematics Understanding (TMU) was used as the main instrument for data collection. Data obtained was analysed using simple frequencies and percentages, correlation and regression analysis, as well as inferential statistics. The results indicated a significant inverse association between students' perception of Mathematics and their performance in Economics. Students' performance in Mathematics was also found to have a positive impact on students' performance in Economics. The study also revealed that

programme of study influence significantly, students' performance in both Economics and Mathematics. It was recommended that all Economics students at the senior high school level study Mathematics as an elective course to enable them improve their performance in Economics.

Introduction

The need to devise efficient and judicious strategies for managing scarce resources is a societal conundrum that has persisted since time immemorial. This may be attributed to the fact that human wants are unlimited and virtually insatiable. People as well as countries have the need for more and better quality goods and services such as better food, clothing, housing, schooling, health care and entertainment. These goods and services can only be obtained through the use of resources such as Land, Labour, Capital and Entrepreneurship which are scarce relative to the demand for them, and need to be effectively managed.

Economics mainly aims at explaining human behaviour in the face of scarcity of resources and fashioning out effective ways of managing these scarce resources to satisfy unlimited human wants. It is acknowledged that knowledge of Economics and ability to apply it to significant problems and issues are essential elements of responsible citizenship in a democratic society. Citizens must be able to comprehend and use basic economic concepts in order to perform adequately as producers, consumers, investors, and voters in public elections. It is believed that widespread improvements in ability to perform these roles would yield enormous benefits to individuals and foster national development (Yidana & Acquah, 2010).

Economics uses a number of approaches for displaying of economic data. One of such approaches that are steadily gaining grounds is the use of mathematical language. According to Stuparu and Daniasa (nd), Mathematics first took on a significant role in Economics in the last century in the build-up to the Marginalist Revolution. This has been described as a period in which classical concerns with production, growth, and the distribution of the fruits of growth among social classes, were being replaced by concern for market exchange. The focus thus shifted from the level of the economy and social classes to the level of the individual. Leon

Walras, in particular, set out to establish the conditions for a successful co-ordination of market exchange, and he did so mathematically. Along with Augustin Cournot, he is believed to be responsible for the introduction of the systematic application of Mathematics to Economics.

Furthermore, there was a strong drive to perceive Economics as a science, in a desperate attempt to bring the discipline at par with the physical sciences. Mathematics was perceived as the means for achieving this objective (Drakopoulos, 1991). With the passage of time, Mathematics has acquired a special position in Economics theorizing and analysis. Woodrow (2003) is of the opinion that, Economists use Mathematics not to formulate, not to theorise, but essentially to describe their world. Economists thereby invoke all the security and certainty that is embedded in popular conceptions of Mathematics but with no axiomatic basis and little predictability. Woodrow however acknowledges the fact that the subject has become entwined and identified with market Economics. This presupposes that Mathematics is a very important phenomenon to the study of Economics

Modern Economics thus relies heavily on Mathematics, but measurement problems, and more fundamental methodological problems, have created a division between pure theory and applied theory. While the former constructs sophisticated mathematical analysis of individual behaviour based on utility maximisation principles, with an emphasis on existent proofs, the latter focuses on the reduced forms for which there are corresponding data. Given the different aims of the two activities, the Mathematics employed in pure theory will thus tend to differ from that employed for the purposes of statistical testing. Backhouse (1998) refers to the increasing propensity to separate the 'pure theory' part of an investigation from the 'empirical' part even within individual articles. A close examination of the above history and interconnection between these two subjects brings to the fore the effect of such a relationship on the achievement of students in Economics.

Again, economists like Keynes used Mathematics to develop models to represent the workings of the economy as a whole. He provided the foundations for modern Macroeconomics, which focuses on the economy in aggregate, rather than parts. He also set out a policy agenda for

government which required that the theory be tested and applied empirically. On this basis, elaborate mathematical models of the economy were constructed. With such an elevated level of mathematical relationship with Macroeconomics, a high level of students' performance is likely to be observed.

The above argument suggests that the close link between Mathematics and Economics may result in a relationship between students' performance in Economics and Mathematics. Thus, a student with a good mathematical background may perform well in Economics as compared to those without such a background. According to Walras (1965), the only way for students to understand certain concepts in Economics is through the help of Mathematics. This tends to reinforce the importance of the Economics-Mathematics relationship to students' performance. According to Cohn, Cohn, Balch and Bradley (1998), data from two sections of principles of Economics at the University of South Carolina during the Spring semester of 1995 were employed to test conflicting results in the literature regarding the effect of Mathematics background on learning. Two measures of Mathematics background and an expanded list of explanatory variables were used. After controlling for SAT scores and GPA, among other variables, they found no significant effects of mathematical background on learning in principles of Economics. However, a study conducted by Lagerlof and Seltzer (2008) reveals that the level of and performance in Mathematics courses taken prior to university have strong predictive power on student performance in a range of Economics courses. Again, a study conducted by Bachan and Reilly (2003) revealed that prior attainment at GCSE level and performance in GCSE Mathematics exert a strong influence on A-level achievement in Economics.

Moreover, past experience and related literature seem to suggest that there exists an interesting relationship between students' performance in Mathematics and their performance in Microeconomics. Microeconomics, which is a branch of Economics, deals with the individual units in the economy. In relevant literature, topics like Consumer Behaviour, Theories of Production, Cost and Market Structures uses Mathematics to bring to bear their relevance in the day to day analysis of the economy.

Also, an individual's perception about a subject, it is believed, has a tremendous effect on his/her performance in the subject. According to Wetzel, Potter and O'Toole, (1982); and Charkins, O'Toole and Wetzel (1985) there is a positive relationship between students' attitude (perception) and performance, in that a students' perception influences his attitude towards a subject and therefore affects his/her performance. A positive perception affects performance positively while the opposite is true. It may therefore be assumed that, since there seem to be a relationship in students' performance in Mathematics and Economics, one's perception about Mathematics could have an influence on the person's performance in Economics.

Another variable of interest was the influence of programme of study on students' performance in Mathematics and Economics. There seem to be the general assertion that Business courses tend to be more mathematically oriented than General Arts courses, hence Business students are more likely to perform relatively better than General Arts students in Mathematics and consequently in Economics. A study conducted by Yanker, Yanker and Krull (2009) however found no statistically significant effect of performance in Mathematics on performance in Accounting, which is a Business subject. This presupposes that Business students with relatively stronger background in Mathematics may not necessarily do any better than General Arts students in Economics or Mathematics.

Rhodd, Schrouder and Allen (nd) assert that the spillovers between the topics in Principles of Economics courses and the topics in International Business, Finance, and Accounting as the method of analysis and the ways of understanding are common. They therefore believe that the performance of students on the Principles of Economic courses could be correlated with their overall performance. Hence grades earned in these Principles of Economics courses could serve as a useful predictor of a student's overall success in the Business curriculum. The speculation gains additional strength when reference is made to the research by Didia and Hasnat (1998) in which a sample of 210 students was used to determine the factors that affected the performance in the university Introductory Finance course. Among the independent variables were the Principles of Economics courses. The ordinary least squares and ordered-probit estimation techniques reveal a strong positive relationship between performance in the Finance course and

Principles of Microeconomics and Macroeconomics courses. As indicted by Didia and Hasnat (1998: 105), "the results suggest that Business programmes may have a justification for requiring students to complete Principles of Economics… before they take introductory finance courses". This goes to buttress the point that Business students are more likely to perform better in Economics than General Arts students as a result of the close association between topics in Business related courses and Economics.

The Problem

Economics is perceived to be very demanding, requiring students to master and apply abstract concepts to real life situations. In addition, many of these concepts are presented in a mathematical context and require a good command of Mathematics. Consequently, there seems to be a general perception that Economics is mathematically intensive, and mathematically underprepared Economics students are sure to struggle in the subject at the senior high school level, and more importantly at the college level. Hence this study set out to find out whether there was any significant association between students' performance in Mathematics and Economics at the senior high school level. Since performance at the senior high school level may serve as a predictor of performance at the college level, it was imperative to determine the association between students' performance in Mathematics and Economics so as to determine what could be done to improve students' performance in Economics both at the senior high school and tertiary levels.

Research Questions/ Hypotheses

The following research questions and null hypotheses guided the study:

1. What is the effect of students' performance in Mathematics on their performance in Economics?
2. What is the association between students' perception of Mathematics and their performance in Economics?
3. Ho: there is no significant difference in the performance of Arts and Business students in Mathematics.

4. Ho: there is no significance difference in the performance of Arts and Business students in Economics.

The Method

The study sought to ascertain the relationship between senior high school students' performance in Mathematics and Economics. Since the target population for the study was large, a descriptive survey was deemed to be more appropriate. As indicated by Macmillan (1996), "In a survey, the investigator selects a group of respondents, collects information, and then analyses the information to answer the research questions" (p. 102). Also, since the study involved a survey of students' knowledge in Mathematics and Economics, the descriptive survey design as suggested by Osuala (1993) was found to be more appropriate. The descriptive survey provides opportunities for researchers to gain valuable insight into the existing state of a phenomenon, "providing background information about the issue in question as well as stimulating explanations" (Sarantakos, 1997, p. 6).

Participants

The target population for the study consisted of all form three SHS students reading Economics in the Sekondi-Takoradi Metropolis. Form three students were selected because they were said to have covered most of the topics in the Economics syllabus and might be more conversant with most of the concepts in the subject. Because the population size was too large, it became necessary for the researcher to select a representative sample that would make it possible for the results to be generalised.

Four senior high schools in the Sekondi-Takoradi Metropolis were selected by means of purposive sampling. This sampling procedure was used to ensure that both mixed and single-sex schools were fairly represented in the study. It was also an attempt to build up a sample that was suitable enough to provide the information required to effectively answer the research questions. The four schools selected were: Ghana Secondary Technical School (GSTS), Archbishop Porter Girls Senior High (APGSH), Fijai Senior High School and Sekondi College.

With regard to the selection of the student respondents, simple random sampling procedure was used in the single-sex schools, whereas stratified random sampling procedure was used in the mixed schools to ensure a fair representation of both male and female students. These sampling strategies were also employed to give each member of the population an equal chance of being selected for the study. The distribution of study sample from the various schools is presented in Table 1.

Table 1: Distribution of Sample for the study

Name of School	Type of School	Sample Used
GSTS	Single-Sex (Male)	92
APGSH	Single-Sex (Female)	92
Fijai SHS	Mixed	92
Sekondi College	Mixed	92
Total		368

The total sample for the study was 368, made up of 92 students from each school. Again, of the total number of respondents, 180 (48.9%) were females, whereas 188 (51.1%) were males.

Instruments

A questionnaire, which consisted of close-ended items, was the main data collection instrument for the study. The questionnaire sought to elicit background information of students and also contained test items to measure students' level of knowledge in Principles of Economics and Core Mathematics at the Senior High School level. The questionnaire was divided into three main sections. Section "A" elicited the background information of students. The major variables of interest were gender of students, age, class/form, programme of study as well as students' perceptions about the learning of Economics. Section "B" contained 60 multiple-choice test items which sought to test students' Economic understanding. The test items covered both micro and macro Economics concepts. The test for students' understanding of Mathematics was contained in section "C" of the questionnaire. This was also made up of 60 multiple-choice test items. The main reason for the choice of the multiple-choice questions was to ensure full

coverage of the course contents outlined in both the Economics and Core Mathematics syllabi. The choice of the multiple-choice test as the means for determining students' achievements in Economics and Mathematics respectively was also informed by the problem of time constraint. Most of the school heads were not ready to give more than two hours to enable the researchers administer the instrument. This made it very difficult to include essay-type questions to test students' writing and reading skills as well.

Procedure

The Test of Economics Understanding (TEU) and a Test of Mathematics Understanding (TMU) were designed by the researchers to measure students' achievements in Economics and Mathematics respectively. These tests were very useful for measuring students' achievements because as suggested by Yidana (2010), the TEU, helps to determine the extent of attainment of the cognitive objectives as spelt out in the Senior High School Economics syllabus. The instrument was pilot-tested to enable the researchers and experienced Economics and Mathematics teachers to refine the items and confirm content validity.

The instrument was administered by two research assistants. The main reason for the personal administration was to give the researchers the opportunity to clarify items in the instrument and to also achieve a high return rate. First, a letter was sent to heads of the four schools to seek permission and to gain familiarity with both the students and teachers. Students were given orientation on how to respond to the various items. Respondents were given two hours, thirty minutes to respond to the items, after which the questionnaires were retrieved by the researchers. This ensured a 100% return rate.

Analysis of Data

Data obtain from the instrument was analysed by simple frequencies and percentages, correlation and regression analysis, as well as inferential statistics. Students' background information was analysed by means of simple frequencies and percentages. Spearman's rank correlation coefficient was used to assess the association between students' perception of Mathematics and their performance in Economics. A regression analysis was used to test the effect of students'

performance in Mathematics on Economics. The independent samples t-test was used to test the two null hypotheses formulated for the study.

Results

Research Question 1: What is the effect of students' performance in mathematics on their performance in Economics?

Table 2: Summary of the Effect of Students' Performance in Mathematics on their Performance in Economics

	Coefficient	Std. Error	Beta	t-value	Sig
(Constant)	27.890	2.016		13.832	.000
Performance in Mathematics	.475	.039	.535	12.111	.000

The estimated regression equation is given as y = 27.890 + .475x

Where y = Students' performance in Economics

x = Students' performance in Mathematics

The t-values and significant values provided in Table 2 indicate that the estimated parameters are significant at the .05 alpha levels. The estimated regression line indicates that a student who performs well in Mathematics will have his/her score in Economics increase by .475. Thus performance in Mathematics can be used to predict a student's performance in Economics and there will be no errors associated with such a prediction at the .05 alpha levels (.000 < .05). The Beta value of .535 also indicates that performance in Mathematics has a significant positive impact on performance in Economics.

Research Question 2: What is the association between students' perception of mathematics and their performance in Economics?

Before this research question could be effectively answered, it is imperative to determine students' perception of both Economics and Mathematics

Table 3: Summary of Students' Perception of Economics and Mathematics

Subject	Economics		Mathematics	
	F	%	F	%
Difficult	153	41.6	165	44.8
Not Difficult	215	58.4	203	55.2
Total	368	100	368	100

Table 3 indicates that majority of students perceive both Economics and Mathematics as subjects that are not difficult to study. This is because 215 (58.4%) and 203 (55.2%) perceive Economics and Mathematics as not difficult to study respectively, as compared to the 153 (41.6%) and 165 (44.8%) who responded otherwise. This finding does not agree with the view of Phipps and Clark (1993) that students see Economics as a very difficult subject because of its Mathematical nature. Since students perceive Mathematics not to be difficult to study, there is the need to find out the association between this perception and their performance in Economics

Table 4: Summary of the Association between Students' Perception of Mathematics and their Performance in Economics

			Perception of Mathematics	Economics Test Score
Spearman's rho	Perception of Mathematics	Correlation coefficient	1.000	-.289
		Sig. (2-tailed)		.000
		N	368	368
	Economics Test Score	Correlation coefficient	-.289	1.000
		Sig. (2-tailed)	.000	
		N	368	368

Correlation is significant at the .05 level (2-tailed)

From Table 4, a Spearman's Rank correlation coefficient of -.289 indicates a weak inverse association between students' perception of Mathematics and their performance in Economics.

This implies that students who perceive Mathematics not to be difficult are more likely to perform poorly in Economics as compared to students who perceive Mathematics to be difficult. The association is significant at the .05 alpha level (.000 < .05).

Hypothesis 1: H_o: there is no significant difference in the performance of Arts and Business students in Mathematics

Table 5: Summary of the results on the performance of Arts and Business students in Mathematics

Programme of Study	M	SD	T	Df	ρ
General Arts	45.9590	14.12457	-5.227	366	.000
Business	53.3931	13.02352			

Significance level .05

From Table 5, the Levene's Test for Equality of variances was used to determine whether the difference in performance was significant. The test indicated that the variances for the two groups were equal (F = .718, ρ > .05), and therefore a test for equal variances was used. The mean performance of Business students in Mathematics (M = 53.3931, SD = 14.12457) is significantly higher (t = -5.227, df = 366, two-tailed probability < .05) than the performance of General Arts students in Mathematics

Hypothesis 2: H_o: there is no significant difference in the performance of Arts and Business students in Economics

Table 6: Summary of the results on the performance of Arts and Business students in Economics

Programme of Study	M	SD	T	Df	ρ
General Arts	49.0359	11.28697			
Business	54.0116	13.31985	-3.840	338.979	.000

Significance level .05

From Table 6, the Levene's Test for Equality of variances was used to determine the significance of the differences in performance. The test indicated that the variances for the two groups were unequal ($F = 6.085$, $\rho < .05$), hence a test for unequal variances was used. The mean performance of Business students in Economics ($M = 54.0116$, $SD = 11.28697$) was significantly higher ($t = -3.840$, $df = 338.979$, two-tailed probability $< .05$) than that of General Arts students.

Discussion

The study reveals that students' performance in Mathematics has a significant positive impact on their performance in Economics. This contradicts findings made by Cohn, Cohn, Balch and Bradley (1998) that there is no significant effect of mathematical background on learning in Principles of Economics. The finding, however, supports conclusions made by Lagerlof and Seltzer (2008) that the level of and performance in Mathematics courses taken prior to university have a strong predictive power on students' performance in a range of Economics courses taken at the university level. A study conducted by Bachan and Reilly (2003) revealed that prior attainment at GCSE level and performance in GCSE Mathematics exert a strong influence on A-level achievement in Economics. This positive effect of performance in Mathematics on performance in Economics may be attributed to the fact that Mathematics plays a significant role in most theorizing in modern Economics and therefore occupies an unequivocal position in most economic analysis. This may clearly explain why students who perform well in Mathematics tend to do well in Economics.

The study also reveals that there is an inverse association between students' perception of Mathematics and their performance in Economics. The implication of this is that students who perceive Mathematics as a subject which is not difficult to study are more likely to perform poorly in Economics as compared to students who perceive Mathematics to be difficult to study. It may be argued that students who perceive Mathematics not to be difficult might not devote much attention to the learning of the subject as compared to students who perceive the subject as difficult to learn. Consequently, they may not perform well in Mathematics, and this could eventually have a negative effect on their performance in Economics. This is because, as already

suggested by the study, high performance in Mathematics translate into high performance in Economics and vice versa. This finding belies the claim of Wetzel, Potter and O'Toole, (1982); as well as Charkins, O'Toole and Wetzel (1985) who found out that positive perception influences performance positively.

The study found a significant difference in the performance of Business and General Arts students in Mathematics. That is, Business students perform significantly better than General Arts students in Mathematics. This difference in performance may be attributed to the fact that Business students offer more Mathematics related subjects such as Accounting and Costing, whereas General Arts students, more often than not, take more reading courses such as History, Government and French. Business students may therefore be more exposed to more content in Mathematics than the General Arts students.

It also became evident in the study that Business students perform significantly better than General Arts students in Economics. This difference in performance could result from the differences in performance in Mathematics between the two programmes. As revealed by the study, performance in Mathematics has a significant positive impact on performance in Economics. It is therefore not surprising that Business students perform better than General Arts students in Economics. It is clearly obvious that Business students have an advantage in Mathematics. This finding agrees with Didia and Hasnat (1998) who found an association in the performance of students in Business related courses and Economics courses.

Conclusion

The thrust of the study was to establish the relationship between students' performance in Mathematics and their performance in Economics. Regression analysis, non parametric correlation procedure (Spearman's Rank Correlation), as well as the independent samples t-test were used to analyse the data. The results indicated that students' performance in Mathematics has a significant positive impact on their performance in Economics.

This study brings to light an inverse association between students' perception of Mathematics and their performance in Economics. The implication of this is that students who perceive Mathematics as a subject which is not difficult to study are more likely to perform poorly in Economics as compared to students who perceive Mathematics to be difficult. The study has also revealed a statistically significant difference in the performance of Business and General Arts students in Mathematics and Economics, with Business students performing better in both subjects.

Pedagogical Implications

The finding that achievement in Mathematics has a positive effect on performance in Economics produces a number of implications for teaching Economics. Mathematics should form an integral part of the learners' orientation towards the learning of Economics at the senior high school level. Economics students must be encouraged to take Mathematics seriously through counselling and motivational strategies such as the use of teaching and learning resources that sustain learners' interest in the classroom. Walbert and Ostrosky (1997), for instance stress the use of technology as a pedagogical tool in Economics as the use of technology in instruction has become ubiquitous due to the increasing accessibility of information via the web and the plethora of software available for analyzing this information. Researches in Economics and mathematics explain how technology aids learning and why some classroom objectives may be achieved more easily when technology is used to complement lecture materials in the classroom (Goffe & Sosin, 2005).

Active learning techniques should be employed by Economics teachers when teaching Mathematics related concepts in Economics to enhance students' performance in the subject. As Siegfried (1998) suggests, most economists would agree that the most important goal of Economics education is to enable students to develop the ability to think like economists. This involves the development of problem-solving skills that stress analytical reasoning in order to understand economic relationships. This type of thinking is facilitated by providing numerous opportunities for students to apply economic concepts to a variety of new situations so that they

learn how 'to do' Economics as well as courses like Mathematics which increase both the breadth and depth of knowledge in Economics.

Elective Mathematics should be made compulsory for Economics students offering General Arts. This is because, as indicated in the study, Business students perform better in both Economics and Mathematics than General Arts students. This disparity in performance has been attributed to the fact that Business students are more exposed to more content in Mathematics through the study of subjects like Accounting and Costing, whereas General Arts students study pure Arts courses such as History, Ghanaian language, French and Christian Religious Studies. Even though some General Arts students read Elective Mathematics, an introduction of all General Arts students to the subject may improve the performance of most students in Mathematics and Economics and also erase the misconception that the General Arts programme is purely a reading course.

Economics teachers must have a good mathematical background because some teachers who do not like Mathematics tend to teach more of the reading aspects of Economics than the mathematical aspects. This may induce students to avoid the mathematical component in the subject and develop the notion that Economics is a difficult subject. Also, school authorities should make sure that students who intend to offer Economics have good mathematical background, since such knowledge has a bearing on students' performance in Economics.

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