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Archbishop Porter Girls' Senior High School Students' Perception of Difficult Concepts in Senior High School Further Mathematics Curriculum in Ghana

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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Abstract

Further Mathematics is frequently perceived as a subject set aside for some exceptional individuals. It often induces feelings of worry; nervousness and panic among students. This study employed the survey research design aimed at investigating difficult concepts in senior secondary school further mathematics curriculum as perceived by students in Archbishop Porter Girls' Senior High School in Ghana. The study was guided by two research questions and the sample for the study was 100, all of who were females. The instrument used for the collection of data was a 37-item questionnaire tagged Difficult Concept Identification Questionnaire in Further Mathematics (DCIQFM). The data obtained were analyzed using Mann Whitney's U test average rank values for determining difficult concepts and perceived causes of further mathematics. Cronbach's Coefficient Alpha was used to estimate the reliability of the study which was found to be 0.754. The findings revealed Conic Section as the most perceived difficult concept in the further mathematics curriculum in Ghana. Other perceived difficult topics were Binomial Theorem, Sequence and Series, Calculus, Trigonometry and Combination (and permutation and their applications). Again, large class size was identified as the main cause of the perceived difficulty sense students have towards further mathematics. Non-science students perceived further mathematics concepts as more

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difficult than the science students. Based on the findings of the study, it was recommended among others that workshops should be organized to train mathematics teachers on the effective and efficient strategies that should be adopted for the teaching of the identified difficult mathematics concepts.

Keywords: Perception; difficult concept; curriculum; further mathematics; Mann Whitney's U statistic; SHS.

1 Literature Review

Analyzing a Likert data requires one to understand the measurement scale represented by each. Numbers assigned to Likert-type items express a "greater than" relationship. Nonetheless, how much greater is not implied. Because of these conditions, Likert-type items fall into the ordinal measurement scale. Descriptive statistics recommended for ordinal measurement scale items include a mode or median for central tendency and frequencies for variability. Additional analysis procedures appropriate for ordinal scale items include the Mann Whitney U test, chi-square measure of association, Kendall Tau B, and Kendall Tau C [1].

The beliefs and attitudes of students towards mathematics teaching and learning play a crucial role in mathematics education [2]. The learning outcomes of students are strongly related to their beliefs and attitudes towards mathematics. A lack of adequate mathematical skill and understanding affects one's ability to make critically important educational, life, and career choices. Students' views of mathematics are important as they can shape the way in which they learn mathematics. Such views and perceptions may have more influence than knowledge in determining how individuals organize and define tasks. Students fall below their expected level of mathematical achievement for a variety of reasons. When asked why they were not as successful in learning mathematics, many people answer that they 'never understood math' or 'never liked it because it was too difficult and did not relate to them'. Some students believe that their mathematical achievement is attributable to factors beyond their control. Evaluation and assessment of students' mathematical knowhow must be made with the awareness of their beliefs [3]. Not only the `cold cognitions´ such as the contents of various subjects and academic skills taught at school, but also a variety of `hot cognitions´ that develop in the school context, and also play an important role in school achievement. For example, achievement-related beliefs and strategies, including self-related beliefs, expectations and emotions, seem to play an important role in low achievement and learning difficulties. Early intervention in learning difficulties and negative self-beliefs may prevent problems in learning [4]. Uchegbu et al. [5] sought to find the perception of difficult topics in Chemistry curriculum in Imo State (Nigeria). In their study, the grand mean was used as the criterion for identifying difficult concepts in the chemistry curriculum. The findings of their study suggested that students find some topics in chemistry difficult and the factors that caused the perceived difficult topics in chemistry curriculum insufficient qualified and practical oriented chemistry teacher, nonfunctional laboratories, poor teaching methods and nonuse of instructional materials [5]. Clement and Omenka [6] on the other hand did a study on Mathematics Teachers' Perception of Difficult Concepts in Secondary School Mathematics Curriculum in Benue State of Nigeria. The study was carried out in Benue State of Nigeria. Two hundred and five mathematics teachers at the secondary school level were involved in the study. Furthermore, the secondary school mathematics teachers spanned seventy-seven schools in the state. The average years of mathematics teaching experience was observed to be 5.8 years and the average teaching load in mathematics for the subject in the study sample was 20.5 periods per week. However, a large number of the teachers had less than four years of working experience at the secondary school level. In addition, it was observed that some returned copies of the instrument used for the study were not properly completed by the respondents. Coupled with such observations and the needed teaching experience in mathematics, the number of teachers in the sample was reduced to ninety five. Secondary school education spans six years in Nigeria and for a mathematics teacher to adequately address the items on the research instrument, he/she might have taught in the school for at least five years. It was as such conjectured that the subjects in this study sample had enough experience in the mathematics teaching and would competently respond to the items on the instrument. The teachers' judgments were treated consecutively and simultaneously along the dimensions of importance and difficulty [6]. The research questions were used to make inference about how teachers deal with each topic or category of mathematics contact in the school curriculum. The instrument used for this study was called Mathematics Content Survey Questionnaire (MCSQ). Four major mathematics curriculum categories (algebra, number and numeration, statistics and geometry with trigonometry) were on the instrument. Each macro content areas contained specific/micro content items. Number system contained 14 items, algebra 12 items, statistics had six items and geometry coupled with trigonometry contained 29 items because of the series of theorems and constructions to be learned by the students. In all, the instrument contained 61 mathematics learning items. The major findings of their study was that the mathematics teachers in the study sample showed a weak agreement in their judgment of only five of the mathematics learning items presented in the questionnaire. There was almost no agreement in their categorization of the remaining 56. Their study suggested service programmes, teacher vacation courses and workshops to reduce the difference in cognitive reviews and levels of subject matter knowledge among mathematics teachers. Failures in Mathematics have been a major canker in Ghana's educational system and a major worry for stakeholders in the country [7].

2 Statement of the Problem

In Ghana, the Science, Technology and Mathematics Education (STME) clinic is organized yearly to address the problem of low participation in mathematics related courses. In spite of these efforts participation in further mathematics at the Secondary School level is not encouraging. Perceptions of what mathematics is and is not, may affect attitudes, performance, confidence and perceived usefulness of mathematics. The findings of this study will reflect possible implication for mathematics education and mathematics teacher education. Knowing how students perceive mathematics learning experiences in school. Therefore, the main aim of this study is to explore and identify the range of perceptions, beliefs and attitudes towards further mathematics as it is perceived by the secondary school students. In that regard, the findings will enable relevant educational stakeholders to identify the topics in Further Mathematics that Workshops for Mathematics Teachers should be targeted at.

The purpose of the study was to investigate the difficult concepts in senior secondary school further mathematics curriculum as perceived by students. Specifically, the objectives of the study are to:

1. Find out the difficult concepts in further mathematics in the senior secondary school curriculum as perceived by the students.
2. Ascertain the causes of the identified difficult mathematics concepts in the senior secondary school curriculum as perceived by the students.
3. Find out if there is any significant difference between concepts perceived as difficult by science and non-science students.

3 Methods and Materials

The study employed survey design. A sample of 100 students was obtained by convenience sampling from the (SHS 3 Final year) students of Archbishop Porter Girls' Senior High School who offered Further Mathematics subject. The data obtained were measured on ordinal scale and were analyzed using Mann Whitney's U test average rank values for determining difficult concepts and perceived causes of difficulty in understanding concepts in further mathematics.. Microsoft Excel and SPSS software were used in the analysis of the data. The five point -Likert scale were coded as strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, strongly Disagree =1. Others are very difficult = 4, difficult = 3, less difficult =2, and not difficult = 1. The study was guided by two research questions and the sample for the study was 100 all of who were females. The instrument used for the collection of data was a 37-item questionnaire tagged Difficult Concept Identification Questionnaire in Further Mathematics (DCIQFM). After developing these instruments, the content and face validity was done by four experts to determine the appropriateness of the instruments. **C**ronbach's Coefficient Alpha is an extension of the split-half method of estimating reliability. Using one pair of random halves of the items is likely to differ from that obtained using another pair of random halves of the items. One solution to this problem is to compute the Spearman-Brown corrected split-half reliability coefficient for every one of the possible split-halves and then find the mean of those coefficients. This mean is known as Cronbach's coefficient alpha. Spearman Brown correction is given by

$$\boxed{r_{sb} = \frac{2r_{hh}}{1+r_{hh}}}.$$

Where r_{hh} is the split half coefficient.

The first step in the rank sum test is to merge the two samples, arraying the individual scores in rank order. The test is then carried out in terms of the sum of the observation in either of the two samples. The following symbolism is used:

n_1 = number of observations in sample number one

n_2 = number of observations in sample number two

R_1 = sum of the ranks of the items in sample number one

R_2 = sum of the ranks of the items in sample number two

If the null hypothesis that the two samples were drawn from the same population were true, we would expect the totals of the ranks (or equivalently, the mean ranks) of the two samples to be about the same. In order to carry out the test, a new statistics, *U* is calculated. This test statistic, which depends only on the number of items in the samples and the total of the ranks in one of the samples, is defined as:

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

The statistic *U* provides a measurement of the difference between the ranked observations of the two samples and yields evidence about the difference between the two populations distributions. Very large or very small *U* values constitute evidence of the separation of the ordered observations of the two samples. Under the null hypothesis, it can be shown that the sampling distribution of *U* has a mean equal to

$\mu_U = \frac{n_1 n_2}{2}$ And a standard deviation of $\sigma_U = \sqrt{\frac{n_1 n_2 (n_1+1)}{12}}$

[8].

Data analysis is performed using Microsoft Excel (windows 10) and IBM SPSS STATISTICS (2015), V23.0, SPSS Inc.

4 Results

From Table 1, the Likert Very Difficult (VD) and Difficult (D) showed significance and so were selected for Mann Whitney U test for further study.

The Mann-Whitney U test is used to find whether or not two independent samples have come from symmetrical populations that have equal means or medians. The test is used when the assumption of two normal populations with equal variances cannot be verified. The data was measured on an ordinal scale, making the test quite useful for ordinal, or ranked data.

Table 1. Concepts in further mathematics syllabus as perceived by students of Archbishop Porter Girls' School

S/N	Topic	Very difficult	Difficult	Less difficult	Not difficult
1	Surds	0	6	42	68
2	Indices	0	6	50	61
3	Logarithms	20	60		25
4	Binary operation	0	9	38	66
5	Coordinate geometry	25	81	92	13
6	Binomial theorem	60	69	64	21
7	Matrices	4	21	50	49
8	Sequence and series	28	87	68	13
9	Calculus	32	75	84	10
10	Probability	12	42	92	25
11	Statistics,	12	36	80	35
12	Vectors	0	57	70	32
13	Mechanics	20	63	76	20
14	Sets and operations	0	3	22	73
15	Trigonometry	28	69	80	13
16	Mapping, functions and Relations	0	27	64	42
17	Quadratic functions and Equations	16	24	72	40
18	(Conic Section) Parabola, Circle and Loci	56	102	50	6
19	Polynomial Function	4	60	70	32
20	Partial Fraction	8	21	46	53
21	Permutation and Combinations	32	63	62	15

Table 2. ANOVA table of differences between means of perception of concepts in further mathematics subject

		Sum of squares	df	Mean square	F	Sig.
VD	Between groups	6302.000	16	393.875	34.250	.002
	Within groups	46.000	4	11.500		
	Total	6348.000	20			
D	Between groups	17315.786	16	1082.237	12.942	.012
	Within groups	334.500	4	83.625		
	Total	17650.286	20			
LD	Between groups	5945.143	16	371.571	.329	.952
	Within groups	4520.000	4	1130.000		

Table 3. Identification of difficult concepts by sum rank test (Mann-Whitney U Test)

S/N	Sample 1	Sample 1 ranked	Sample 2	Sample 2 ranked	Mean rank	Decision
1	0	3.5	6	10.5	7	Disagree
2	0	3.5	6	10.5	7	Disagree
3	20	17.5	60	33	25.25	Disagree
4	0	3.5	9	13	8.25	Disagree
5	25	22	81	40	21.25	Disagree
6	60	33	69	37.5	**35.25**	Agree
7	4	8.5	21	19.5	14	Disagree
8	28	24.5	87	41	**32.75**	Agree
9	32	26.5	75	39	**32.75**	Agree
10	12	14.5	42	29	21.75	Disagree

S/N	Sample 1	Sample 1 ranked	Sample 2	Sample 2 ranked	Mean rank	Decision
11	12	14.5	36	28	21.25	Disagree
12	0	3.5	57	31	17.25	Disagree
13	20	17.5	63	35.5	26.5	Disagree
14	0	3.5	3	7	5.25	Disagree
15	28	24.5	69	37.5	**31**	Agree
16	0	3.5	27	23	13.25	Disagree
17	16	16	24	21	18.5	Disagree
18	56	30	102	42	**36**	Agree
19	4	8.5	60	33	20.75	Disagree
20	8	12	21	19.5	15.75	Disagree
21	32	26.5	63	35.5	**30.875**	Agree

Criterion Ranking Average = 27.90

n_1 = number of observations in sample number one

n_2 = number of observations in sample number two

R_1 = sum of the ranks of the items in sample number one

R_2 = sum of the ranks of the items in sample number two

n_1 = 21, n_2 = 21, R_1 = 317, R_2 = 586

Ranking averages are: $\frac{R_2}{n_2} = \frac{586}{21} = 27.90$ and $\frac{R_1}{n_1} = \frac{317}{21} = 15.10$.

The highest ranking average of 27.90 was used as the criterion for identifying the agreement of the respondents of difficult concept in further mathematics. If this criterion value is equal or higher than the mean rank in Table 3, the topic is considered to be perceived by the respondents as a very difficult or otherwise not very difficult.

Conic Section as the most perceived difficult concept in the further mathematics curriculum in Ghana. Other perceived difficult topics in order of difficulty were Binomial Theorem, Sequence and Series, Calculus, Trigonometry and Combination (and permutation). This is also evident from the bar chart in Fig. 1 and Table 3.

The U statistic is calculated as:

$$
\begin{aligned}
U &= n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \\
&= (21)(21) + \frac{21(21+1)}{2} - 317 \\
&= 441 + \frac{462}{2} - 317 \\
&= 355
\end{aligned}
$$

The parameters of the normal sampling distribution are then computed as follows:

$$\mu_U = \frac{n_1 n_2}{2} = \frac{21(21)}{2} = \frac{441}{2} = 220.5$$

$$\sigma_U = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}$$
$$= \sqrt{\frac{21(21)(21+21+1)}{12}}$$
$$= 39.7524$$

$$Z = \frac{U - \mu_U}{\sigma_U} = \frac{355 + 220.5}{39.7524}$$
$$= 3.38$$

The sample statistic (355) is 3.38 standard deviations above the curve mean of 220.5 if the null hypothesis of equal populations is true.

Since the computed Z value is greater than 1.96, we reject the null hypothesis that the samples were drawn for same populations.

By comparing we observe that $\frac{R_2}{n_2} = \frac{586}{21} = 27.90$ and $\frac{R_1}{n_1} = \frac{317}{21} = 15.10$

Conic Section (Parabola, Circle and Loci) was perceived as the most difficult concept in further mathematics by the SHS students. We could infer that students have problems with at least one of the following areas of the topic;

i. Proof and use of equation of circle of the forms $x^2 + y^2 = r^2$, $(x-a)^2 + (y-b)^2 = r^2$, $x^2 + y^2 + 2gx + 2fy + c = 0$, and other related relationships such as $r = \sqrt{g^2 + f^2 - c}$, where r is the radius , $c = a^2 + b^2 - r^2$, centre C (a,b) = (-g,-f).
ii. Properties of circle equations
iii. Equation of tangents and normal to a circle related problems
iv. Equation of circle passing through three given points , two given points and the equation of a line passing through the centre given
v. Equation of circle touching at least one axes
vi. Interior and exterior points of circles
vii. Equations of parabola and directrix and vertex
viii. Tangents and normal to parabola
ix. Translations of the parabola

Binomial Theorem was perceived as a difficult concept in further mathematics by the SHS students. We could infer that students have problems with at least one of the following areas of the topic;

i. Factorials
ii. Pascal's triangle
iii. Introduction to the formulas below and their usage

1. $(a+b)^n = {}^nC_0a^nb^0 + {}^nC_1a^{n-1}b^1 + {}^nC_2a^{n-2}b^2 + {}^nC_3a^{n-3}b^3 + \ldots + {}^nC_{n-1}a^1b^{n-1} + {}^nC_na^0b^n$

2. $(a+b)^n = a^n + na^{n-1}b + \frac{n(n-1)}{2!}a^{n-2}b^2 + \frac{n(n-1)(n-2)}{3!}a^{n-3}b^3 + \frac{n(n-1)(n-2)(n-3)}{4!}a^{n-4}b^4 + \ldots + b^n$

Note :

i) Both formulars are the same. (ii) Note that this is a finite series and that the last term is b^n.

iv. Introduction to the following formulas and their usage

When n is a positive integer :

$$(1+x)^n = 1 + xn + \frac{n(n-1)}{2!}x^2 + \frac{n(n-1)(n-2)}{3!}x^3 + \frac{n(n-1)(n-2)(n-3)}{4!}x^4 + \ldots + x^n$$

If n is a rational number, and x is a real number such that $x < 1$, then $-1 < x < 1$

$$(1+x)^n = 1 + nx + \frac{n(n-1)x^2}{2!} + \frac{n(n-1)(n-2)x^3}{3!} + \ldots\ldots\ldots$$

v. Application and use of the concept

$$\text{If } \left(a+b\sqrt{c}\right)^n = e + f\sqrt{d}\text{, then } \left(a-b\sqrt{c}\right)^n = e - f\sqrt{d}$$

vi. Finding the term independent of x in a given binomial expression , e.g. $\left(\frac{\sqrt{x}}{\sqrt{3}} + \frac{\sqrt{3}}{2x^2}\right)^{10}$

vii. Finding a particular coefficient of a term in a given expansion

viii. Finding the middle term of a given binomial expression

Calculus was also another area the students perceived difficult. This is rather a broad topic which consist of the following areas:

i. Concepts of limits such as limits to infinity, involving square root, trigonometry of limits
ii. Differentiation from first principle
iii. Power rule, differentiation of sums and differences, products and quotient rules
iv. Differentiation of implicit functions
v. Differentiation of simple trigonometric expressions, and higher derivatives
vi. Maxima and minima, curve sketching, points of inflection and applications
vii. Applications of derivatives in gradient, tangent and normal to curves, linear kinematics
viii. Small changes and applications
ix. Increasing and decreasing functions
x. Small increments and their applications
xi. Parametric and differential equations
xii. Rates of change
xiii. Concept and rules for sum, quotient, power, constants, integration of definite and indefinite integrals
xiv. Area under curve
xv. Integration by substitution
xvi. Integration of simple trigonometric functions
xvii. Applications of integration in volumes of revolution, approximate integration by the trapezium rule

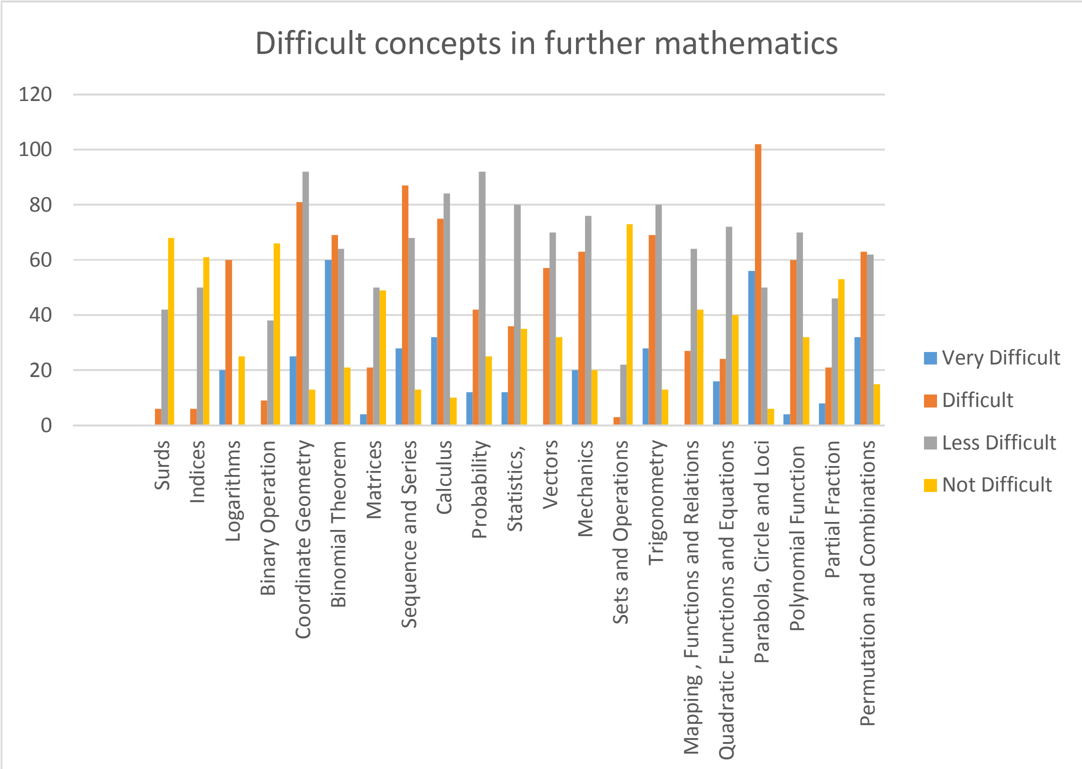

Fig. 1. Graph of difficult concepts in further mathematics

Sequence and Series was yet another perceived difficult topic. This might be the case due to lack of understanding of at least one of the following areas:

i. Recursive rule and sequence with alternating terms and their applications
ii. Series and Summation Notation with applications
iii. Linear series (arithmetic progression), nth term (last term), sum of the first n terms, proofs and applications, properties of A.P
iv. Exponential or Geometric progression, nth term, sum of first n terms, proofs and applications, properties of G.P
v. Inserting Arithmetic and Geometric means
vi. Sum to infinity and applications
vii. Finding the n^{th} term of a sequence other than A.P or G.P
viii. Mixed series and applications

Trigonometry was also found to be a problem area to students. This topic is made up of the following sub-areas:

i. Special angles and their applications
ii. Negative, acute and complementary angles and their application across the four quadrants
iii. Proof of trigonometric identities
iv. Solving trigonometric equations and finding primary and secondary angles and solutions
v. The R-formula and applications to finding minimum and maximum values
vi. Sum to product identities, half angles
vii. Radian measure
viii. Sine and cosine rules and area of triangle

Permutation and Combinations (and their applications) was also perceived as difficult. This topic is made up of the following:

i. Factorial
ii. Concepts and use of combination and permutation
iii. Arrangement around a table, on a bench
iv. Number of ways of forming committees with and without restriction
v. Other applications including in probability

Table 4. Coded responses to the causes of difficulty of concept in further mathematics

S/N	Causes of difficulty of concept in mathematics	SA	A	N	D	SD
1	No matter how much I learn I still don't do so well	125	84	39	26	17
2	Class size was too large	100	84	51	38	13
3	The syllabus will not be completed	230	116	15	16	3
4	Math is just difficult	25	36	84	100	22
5	It is because I have problems in core math	15	92	51	72	20
6	I don't practice math regularly	35	128	51	62	37
7	Lack of math teachers	15	16	27	56	40
8	Lack of mathematics teachers in the school	25	4	9	38	63
9	My math teacher had difficulty with some topics himself/herself	30	60	51	56	23
10	I really don't like E-math	140	172	27	12	5
11	There are some mathematics concepts that do not interest me	80	128	30	30	17
12	Deliberate skipping of some mathematics concepts by teachers	50	96	63	28	22
13	Lack of adequate time to learn due to holding an office in school	120	88	42	36	13
14	Non marking and correction of assignment to find out students strengths and weaknesses in mathematics concepts	5	8	18	34	65
15	My math teacher was not of a specific gender	20	20	36	62	37

Table 5. ANOVA table comparing means of perceptions

		Sum of squares	df	Mean square	F	Sig.
SA	Between groups	55355.833	10	5535.583	13.522	.011
	Within groups	1637.500	4	409.375		
	Total	56993.333	14			
A	Between groups	26939.733	10	2693.973	1.252	.447
	Within groups	8608.000	4	2152.000		
	Total	35547.733	14			
N	Between groups	5061.600	10	506.160	4.890	.070
	Within groups	414.000	4	103.500		
	Total	5475.600	14			
D	Between groups	5071.600	10	507.160	.780	.660
	Within groups	2602.000	4	650.500		
	Total	7673.600	14			

Strongly agree and neutral Likerts were significant and so were used further in the determination of causes of difficult concepts in further mathematics using the Mann Whitney U test.

Table 6. Decision table for causes of difficulty of concept in mathematics

Causes of difficulty of concept in mathematics	Sample 1	Sample 1 ranked	Sample 2	Sample 2 ranked	Mean rank	Decision
No matter how much I learn I still don't do so well	125	28	39	16	**22**	Yes
Class size was too large	100	26	51	20.5	**23.25**	Yes
The syllabus will not be completed	230	30	15	4	17	No
Math is just difficult	25	8.5	84	25	16.75	No
It is because I have problems in core math	15	4	51	20.5	12.25	No
I don't practice math regularly	35	14	51	20.5	**17.25**	Yes
Lack of mathematics teachers in the school	25	8.5	9	2	5.25	No
My math teacher had difficulty with some topics himself/herself	30	12.5	51	20.5	16.5	No
I really don't like further mathematics	140	29	27	10.5	**19.75**	Yes
There are some mathematics concepts that do not interest me	80	24	30	12.5	**18.25**	Yes
Deliberate skipping of some mathematics concepts by teachers	50	18	63	23	**20.5**	Yes
Lack of adequate time to learn due to holding an office in school	120	27	42	17	**22**	Yes
Non marking and correction of assignment to find out students strengths and weaknesses in mathematics concepts	5	1	18	6	3.5	No
No matter how much I learn I still don't do so well	20	7	36	15	11	No

Criterion Ranking Average = 17.1

The U statistic is calculated as:

$$\begin{aligned} U &= n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \\ &= (15)(15) + \frac{15(15+1)}{2} - 256.5 \\ &= 225 + \frac{240}{2} - 256.5 \\ &= 88.5 \end{aligned}$$

The parameters of the normal sampling distribution are then computed as follows:

$$\mu_U = \frac{n_1 n_2}{2} = \frac{15(15)}{2} = \frac{441}{2} = 112.5$$

$$\sigma_U = \sqrt{\frac{n_1 n_2 \left(n_1 + n_2 + 1\right)}{12}}$$
$$= \sqrt{\frac{15(15)(15+15+1)}{12}}$$
$$= 24.495$$

$$Z = \frac{U - \mu_U}{\sigma_U} = \frac{88.5 + 112.5}{24.495}$$
$$= -0.98$$

The sample statistic (88.5) is 3.38 standard deviations above the curve mean of 112.5 if the null hypothesis of equal populations is true.

Since the computed Z value is greater than -1.96, we accept the null hypothesis that the samples were drawn for same populations.

Ranking averages are: $\frac{R_2}{n_2} = \frac{208.5}{15} = 13.9$ and $\frac{R_1}{n_1} = \frac{256.5}{15} = 17.1$

The highest ranking average of 17.1 was used as the criterion for identifying the causes of the difficult concepts in further mathematics. If this criterion value is equal or higher than the mean rank in Table 6, the cause is considered a significant contributor to why further mathematics is perceived to be difficult.

A number of causes of perceived difficult nature of mathematics were identified in Table 6, with the highest contributive factor being large class size.

Table 7. Test of significance among concepts perceived by Science and Non-science students as difficult

	Value	df	P-value
Pearson chi-square	195.000[a]	169	0.083

From Table 7, there is a significant difference between concepts perceived by Science and Non-science students as difficult $\left(\chi^2 = 195.000^a,\ df = 169,\ p > 0.05\right)$.

Table 8. Descriptive Statistics of concepts perceived by Science and Non-science students as difficult

	N	Minimum	Maximum	Mean	Std. deviation
Science	15	5	121	50.10	36.052
Non-Science	15	8	225	93.04	66.954
Valid N (listwise)	15				

From Table 8, Non-science students perceived Further Mathematics concepts as more difficult than the Science students (Mean: 93.04 > 50.10). The deviations from the mean of the perceptions of science and non-science students were respectively 36.052 and 66.954.

Table 9. Test of significance among concepts not perceived by Science and Non-science students as difficult

	Value	df	P-value
Pearson chi-square	165.000[a]	156	0.295

From Table 9, there was a significant difference between concepts not perceived as difficult by science and non-science students. This means non-science perceive as difficult some concepts the science students did not perceive as difficult.

5 Conclusion

This study concludes that there are mathematics concepts that are difficult although the difficulty varies from concept to concept and that students are aware of the factors that can attribute to the concept difficulty.

The study identified topics such as Conic Section, binomial theorem, sequence and series, calculus, trigonometry, and Combination (and permutation and their applications) as difficult topics in the further mathematics curriculum in Ghana.

Identified causes of the causes of difficulty included the following:

- No matter how much I learn I still don't do so well
- Class size was too large
- I don't practice math regularly
- I really don't like further mathematics
- There are some mathematics concepts that do not interest me
- Deliberate skipping of some mathematics concepts by teachers
- Lack of adequate time to learn due to holding an office in school

There was a significant difference between concepts perceived by Science and Non-science students to be difficult $\left(\chi^2 = 195.000^a,\ \mathrm{df} = 169,\ p > 0.05\right)$. Again, comparatively, Non-science students perceived more concepts to be difficult than Science students (Mean: 93.04 > 50.10).

6 Recommendations

Based on the findings of this study, the following are recommended:

1. Workshops should be organized for mathematics teachers to train them on how to effectively teach the identified difficult mathematics concepts which students struggle with.
2. School authorities should endeavor to reduce class-sizes to about 25 or 30.
3. Students should cultivate the habit of solving more questions on their own after they have been taught math.
4. Teachers should make their lessons more interesting and activity based so that students can clear the prejudice that they have that math is the most difficult subject.
5. Measures should be put in place to enable teachers to complete the syllabus before students write their final examinations.
6. Students who are elected to hold positions in schools should be taken through counseling sessions and time management modules so they can blend their academic and administrative skills.

Competing Interests

Author has declared that no competing interests exist.

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