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Conceptions of the Aesthetic Values of Mathematics by University Undergraduates: Case Study of University of Ilorin, Nigeria

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ABSTRACT The study examined the aesthetic values of mathematics as conceived by the undergraduates of University of Ilorin, Nigeria. A total of 513 students (mean age = 23.3 males = 279, and females=234) were selected using stratified sampling technique. However, only 470 respondents participated in the study. The participants responded to a researcher-prepared questionnaire titled "Conceptions of the Aesthetic Values of Mathematics Questionnaire. (CAVMQ). Influences of students' gender, education level and faculty on participants' responses were sought. A group means comparison using t-test and analysis of variance revealed significant differences in participants' conception of the aesthetic values of mathematics based on gender and faculty. Students' education level had no significant influence on respondents' conception of the aesthetic values of mathematics. The post-hoc analysis on faculty shows that the direction of the differences was observed in faculties of Sciences, Agriculture and Engineering. It is, therefore, recommended that learners of mathematics, right from the elementary level of education should be adequately engaged in creative, innovative and inventive activities that would provide them aesthetic experiences of mathematics.

INTRODUCTION

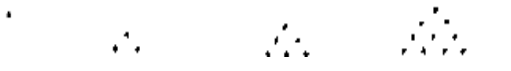
Conception refers to broad understanding or idea of something. The Encarta Dictionary (2009) defines conception as "a result of thought such as an idea or invention or plan." The recognition of the aesthetic values of Mathematics is of interest in the present study. The Oxford Dictionary (2009) defines aesthetic as "se-nsitive to or appreciation of art or beauty." The word "beauty" was defined by Merriam Webster Dictionary as "the quality or aggregate of qualities in a person or thing that gives pleasure to the senses, or pleasurably exalts the mind or spirit. It could be inferred from the definition that beautiful things positively push the emotional buttons of the body. This could be a model, a building, a tree, equations and so forth. The meaning of "beauty" differs in contexts, for example, beautiful babies are emotionally preferable to ugly babies. To assess the beauty of anything means to indicate the mental image or model form concerning its values, goals and ideals. An aesthetic view of Mathematics is the value and beauty involving appreciation of Mathematics (Betts 2004; Ugwanna 2007). The philosophies of absolutism and social constructivism have their views of the aesthetic values of Mathematics. For instance, Plato, an advocate of absolutism assumes that the existence of mathematics is independent of human beings or human activities. This school of thought conceptualized mathematics as the language of the universe that was discovered and not invented (Hardy 1992). Also, Ernest (1991) revealed that the social constructivists believe that Mathematics is fallible and changing, and that mathematical creation is by invention and not by discovery of pre-existing knowledge.

Contrary to the views of the absolutism, Ernest (1998) a proponent of social constructivism viewed the nature of Mathematics as largely based on the philosophies of empiricism, conventionalism and radical constructivism. Mathematics is primarily viewed by the social constructivists as a social construct, product of culture, subject to correction and change. It is also believed that mathematics is an exercise of human intuition, not a game played with meaningless symbols. Lakators (1976) reported that there is a cycle of discovery in mathematics that begins with proofs by primitive conjecture. Also, Enaohwo (2007) conceptualized Mathematics as a subject that is not only concerned with computation but extends to other areas like aesthetics, leadership needs, and legal strategies, scientific and technological development. In the same vein, Uvoh-Gardner (2007) described Mathematics as an instrument that is not equated to computing alone but associated

with problem solving, logical reasoning, beauty, consistency, orderliness, truth, proofs, deductions, decisions, conclusions, brevity, precision and applications. Mathematics also involves the study of patterns such as square and triangular numbers. For example,

$1x1 = 1^2$ $2x2 = 2^2$ $3x3 = 3^2$ $4x4 = 4^2$ $5x5 = 5^2$

Fig. 1. Square number patterns



1 1+ 2 = 3dots 1+2+3= 6dots 1+2+3+4=10dots

1+2+3+4+5= 15dots 1+2+3+4+5+6= 21dots

Fig. 2. Triangular dot patterns

It also draws generalizations from common properties and patterns of common occurrences of particular instances. For instance, a generalization can be derived from Figure 3 below:

$1=1^2$
$1+3=2^2$
$1+3+5=3^2$
$1+3+5+7=4^2$
$1+3+5+7+9=5^2$

Fig. 3. Sum of first n-odd numbers = n^2

Also, Ammari-Allahyari (2006) stated that there is a confluence of Mathematics and nature. According to the scholar, among these natural phenomena which can be easily seen and found around us and has fundamental role in Mathematics include Fibonacci sequence, for example,

1 – Fibonacci Sequence

1, 1, 2, 3, 5, 8, 13, 21, 34, 55, -.-,—,

In the sequence, each term of the sequence is the addition of two successive previous terms. Fibonacci sequence with seed value $a_0 = 0$ and $a_1 = 1$ where $a^n = a_{n-1} + a_{n-2}$

The working definition of the conception of the aesthetic values of Mathematics can, therefore, be stated as the broad or general understanding or idea conceived of the beauty of Mathematics in terms of its usefulness. The National Council of Teachers of Mathematics (2000) reported that providing children the opportunity to express their ideas or understanding of Mathematics through engaging them in activities sometimes enhances their skills in areas such as creating their own algorithms for adding multi-digit numbers, comparing the algorithms of their peers and deciding on which are the "best" based on criteria such as efficiency, ease of use or clarity. It was further explained that the exposure of children to the historical and cultural place of Mathematics may assist to develop their understanding of computational algorithms, other concepts and the opportunity to recognize the aesthetic values of Mathematics. This may in turn motivate their learning and enjoyment of Mathematics. It may also be a modus-operandi of bridging the gap between the popular perceptions of Mathematics as a difficult subject; hence, demystifying it and making it accessible to all learners.

It is believed that Nigerian University Undergraduates have studied Mathematics at the primary and secondary school levels as a compulsory school subject. It is on this premise they are required to indicate their conception of the aesthetic values of Mathematics in terms of its usefulness in daily activities.

The Problem

The low academic performance of students in Mathematics had been of great concern to teachers, examination bodies and parents, being a requirement to study or choose certain career in institutions of higher learning. This could be attributed to students' negative attitudes among other factors, arising from inadequate knowledge of its aesthetic values, its relevance to future aspiration and inadequate conceptual understanding of its contents.

In the same vein, Ammari-Allahyari (2006) submitted that one of the main reasons of Mathematics phobia in the society and among students is lack of the awareness of the beautiful aspects of the subject in terms of textbooks, classrooms and the environment.

Research reports of case studies by Alba (1984) on the correlation between conceptions of Mathematics by high school teachers and its teaching showed that the teachers' beliefs, views and preference for Mathematics and its teachings played a significant role in shaping instructional behaviours. In the light of that, the present study sought information on the conception of the aesthetic values of Mathematics by high school students (university undergraduates) to determine whether or not their conception may

play significant role in the learning process of the subject. The influences of students' gender, faculty and education level were also examined.

Study Objectives

The purpose of this study was to determine the conceptions held of the aesthetic values of Mathematics by undergraduates of the University of Ilorin, Nigeria. Specifically, the study examined the influences of students' gender, faculty and education level on conceptions held of the aesthetic values of Mathematics by the university undergraduates.

Research Questions

- What are the conceptions of the aesthetic values of Mathematics by undergraduates of the University of Ilorin?
- Is there any difference in the conceptions held of the aesthetic values of Mathematics by male and female undergraduates of the University of Ilorin?
- Does the undergraduates' education level have influence on their conceptions of the aesthetic values of Mathematics?
- Does the undergraduates' faculty have influence on their conceptions of the aesthetic values of Mathematics?

Hypotheses

The following hypotheses were tested based on the research questions.

- There is no significant difference in the conceptions held of the aesthetic values of Mathematics by male and female undergraduates of the University of Ilorin.
- There is no significant difference in conceptions held of the aesthetic values of Mathematics by undergraduates of the University of Ilorin on the basis of education level.
- There is no significant difference in conceptions held of the aesthetic values of Mathematics by undergraduates of the University of Ilorin on the basis of their faculties.

METHOD

Design: The study was a descriptive research of the survey type. A researchers-designed questionnaire on the aesthetic values of Mathematics was employed to collect data.

Participants: There were eight faculties in the University of Ilorin at the time this study was conducted. The faculties were: Arts, Law, Business Studies and Social Sciences, Education, Sciences (BSS) Agriculture, Engineering, and College of Health Sciences. Recently, the College of Medicine split into faculties of Basic Sciences and Clinical Sciences, while the faculty of Communication and Information Sciences was newly established. Presently, there are ten faculties in the University of Ilorin. Each of the faculties involved in the study has a minimum of four (4) departments. A minimum of six (6) males and five (5) females were involved as samples in each department for the purpose of adequate representation of the undergraduates in all the departments and faculties in the University.

The target population for the study was all undergraduates of the University of Ilorin. The researcher used stratified sampling technique according to the departments in each faculty, using each department as a stratum from which six males and five females were randomly sampled. Except in the faculty of science that had the largest number of departments, where seven males and six females were randomly sampled from each of the departments under it. The basis for the higher number of male respondents was that there were more male undergraduates than the females.

The breakdown of the number sampled is in Table 1.

Table 1: Sample size according to faculty, department and sex

S. No.	*Faculty*	*Number of departments*	*Number of sampled under graduates*		*Total*
			Male	*Female*	
1.	Agriculture	6	36	30	66
2.	Arts	7	42	35	77
3.	BSS	6	36	30	66
4.	Education	5	30	25	55
5.	Engineering	4	24	20	44
6.	Law	5	30	25	55
7.	Sciences	9	63	54	117
8.	College of Health Sciences	3	18	15	33
Total			279	234	513

Instrument: A researchers-designed questionnaire titled "University Undergraduates' Con-

ceptions of the Aesthetic Values of Mathematics" containing 20 items was used as instrument for data collection. Section A of the questionnaire sought data on students' gender, educational level and faculty, while section B sought data on the aesthetic values of Mathematics. Some of the items read: "Mathematics is a working tool required by every society for survival; Mathematics stimulates constant brainstorming and functional education at all times; the act of doing Mathematics has emotional characteristics of trial and error which sometimes lead to eventual success and so on".

The face and content validation of the items were carried out by two experts in the department of Science Education, University of Ilorin, one in Mathematics Education and the other in Science Education. The reliability value was 0.78.

Procedure: The researchers employed the services of a research assistant who administered the questionnaire forms according to given instructions by the researchers. It is indicated in Table 1 that a total of 513 undergraduates were expected to fill and return the questionnaire forms. But out of the 513 forms administered, only 470 undergraduates fully completed and returned the questionnaire forms, while 19 were returned unfilled and 24 refused to return theirs. The analysis was carried out on only the 470 undergraduates.

RESULTS

Four (4) research questions were raised. The research question one was answered using frequency counts and percentages while research questions two and three were transformed into equivalent hypotheses. Hypothesis one was tested using t-test statistic, while two and three were tested using Analysis of Variance (ANOVA).

Research Question 1: What are the conceptions held of the aesthetic values of Mathematics by the undergraduates of the University of Ilorin?

In answering this research question, frequency counts and percentages of responses to each item of the questionnaire were computed as shown in Table 2.

Table 2 shows the frequency counts and percentages of responses to the 20 items in the questionnaire across the faculties. It is indicated in Table 2 that greater percentage of the respondents chose "Strongly Disagree" and "Disagree" as compared with "Strongly Agree and "Agree". It could be inferred that the aesthetic values of Mathematics were conceptualized differently by the undergraduates.

Further, the responses suggest that greater percentage of the undergraduates do not conceive Mathematics as: a working tool required for survival; an instrument that keeps the brain func-

Table 2: Frequency counts and percentages of responses to each item of the questionnaire according to faculties

Faculties	*Item No.*	*Response scales*								*Total*	*%*
		Strongly agree		*Agree*		*Disagree*		*Strongly disagree*			
		No	*%*	*No*	*%*	*No*	*%*	*No*	*%*		
1-8	1	30	6.3	58	12.3	196	41.7	186	39.6	470	"
1-8	2	43	9.2	102	21.7	201	42.8	124	26.4	470	"
1-8	3	208	44.3	145	30.9	70	14.9	47	10	470	"
1-8	4	112	23.8	104	23.1	186	39.6	68	14.5	470	"
1-8	5	42	8.9	72	15.3	208	44.3	148	31.5	470	"
1-8	6	28	6.0	40	8.5	194	41.3	208	44.3	470	"
1-8	7	14	3.0	74	15.7	196	41.7	186	39.6	470	"
1-8	8	64	13.6	28	6.0	146	31.1	230	49.2	468	"
1-8	9	52	11.1	37	21.8	148	31.5	230	49.2	467	"
1-8	10	48	10.3	122	26.4	219	46.9	78	16.7	467	"
1-8	11	39	7.9	107	22.9	186	39.6	136	29.1	468	"
1-8	12	68	14.5	34	7.3	120	25.7	246	52.6	468	"
1-8	13	48	10.3	49	10.5	131	28.0	240	51.4	468	"
1-8	14	74	15.7	73	15.5	157	33.4	166	35.3	470	"
1-8	15	22	4.7	113	24.0	173	36.8	162	34.5	470	"
1-8	16	70	14.9	134	28.5	182	38.7	84	17.9	470	"
1-8	17	26	5.5	128	27.2	191	40.4	125	26.6	470	"
1-8	18	26	5.5	36	7.7	158	33.6	250	53.2	470	"
1-8	19	12	2.6	150	31.9	184	39.2	124	26.4	470	"
1-8	20	88	18.9	98	20.9	152	32.3	132	28.1	470	"

Table 3: t-test computation on conceptions of the aesthetic values of Mathematics on the basis of gender

Gender	*N*	*Mean*	*Standard deviation*	*Student mean error*	*df.*	*Cal. t-value*	*Sig. level*
1	306	59.44	7.72	0.44	468		
2	164	121.17	560.85	43.80	468	3.88	0.000

tional at all times; a subject that does not exist in a vacuum but has cultural relevance and historical base and a subject that assists to develop the sense of logical reasoning through aggressive brainstorming among others.

Hypothesis 1: There is no significant difference in conceptions of the aesthetic values of Mathematics by male and female undergraduates of the University of Ilorin. This hypothesis was tested using t-test statistics. The result of the analysis is in Table 3.

It is observed in Table 3 that the calculated p-value (0.000) is less than 0.05 i.e. $0.000 < 0.05$. Hence, there was significant difference in conceptions of the aesthetic values of Mathematics by the male and female university undergraduates. Hence, hypothesis one was rejected. This confirmed the assertion by Meyer and Koehler (1990) that males and females have different beliefs about learning mathematics. In the same vein, Leder and Fennema (1990) reported substantial differences in females and males perceptions of Mathematics and their overall abilities.

Hypothesis 2: There is no significant difference in conceptions of the aesthetic values of Mathematics by undergraduates of University of Ilorin on the basis of education level.

This hypothesis was tested using Analysis of Variance (ANOVA). The result is in Table 4.

It is indicated in Table 4 that the calculated p-value (.224) > 0.05. Hence, hypothesis 2 was accepted implying that undergraduates' educational level has no influence on their conceptions of the aesthetic values of Mathematics.

Hypothesis 3: There is no significant difference in conceptions of the aesthetic values of Mathematics by undergraduates of University of Ilorin on the basis of their faculties.

Analysis of Variance (ANOVA) statistics was also used to determine whether students' faculty has influence on their conceptions of the aesthetic values of Mathematics. The result is in Table 5.

It is also observed in Table 5 that the computed p-value (0.007) is less than 0.05, that is $0.007 < 0.05$. Therefore, significant difference exists in conceptions held of the aesthetic values of Mathematics by undergraduates of University of Ilorin in different faculties. A post-hoc analysis was further carried out to determine the direction of the differences among the eight faculties. Table 6 shows the number of respondents in each faculty.

The number of the respondents is unequal because of the different number of departments in each faculty. The Faculty of Science that had the highest number of respondents was the largest faculty in terms of the number of departments. The mean difference shows significant difference in conceptions of aesthetic values of Mathematics within each faculty and among the faculties. The direction of the differences in Table 6 indicated faculties of Agriculture, Sciences and Engineering.

Table 4: ANOVA computation on conceptions of the aesthetic values of mathematics on the basis of education level

	Sum of square	*Df*	*Mean square*	*F-value*	*Sig level*
Between groups	626347.55	4	156586.887	1.426	.224
Within groups	51071420	465	109831.011		
Total	51697768	469			

Table 5: ANOVA computation on conceptions of the aesthetic values of mathematics on the basis of faculty

	Sum of squares	*df*	*Mean square*	*F-value*	*Sig.*
Between Groups	2125731.8	7	303675.969	2.830	.007
Within Groups	49572036	462	107298.779		
Total	51697768				

Table 6: Duncan post hoc analysis on faculties

		Subset for alpha = 05	
Faculty	*N*	*1*	*2*
6.00	24	53.6000	
8.00	46	55.6087	
3.00	70	58.4286	
4.00	90	59.977	
7.00	112	60.6786	
1.00	50	63.2400	
5.00	36	65.6667	
2.00	42		295.4762
Sig.		880	1.000

Key: Agriculture -1 Engineering -5 Arts- 2 Law- 6 Business and Social Sciences - 3 Sciences - 7 Education -4 College of Medicine - 8

DISCUSSION

Out of the 513 undergraduates selected using the stratified sampling technique, only 470 male and female undergraduates returned completed questionnaire forms. The research question one was answered using frequency counts and percentages. Table 2 shows the frequency counts of respondents in the response scales of Strongly Disagree, Disagree, Agree and Strongly Agree. The percentage of respondents to the items affirmed that differences exist in conceptions held of the aesthetic values of Mathematics by the undergraduates of the University of Ilorin.

Hypothesis one was tested by employing t-test statistics. Findings revealed that differences exist in conceptions held by male and female undergraduates of the University of Ilorin. This supports the assertion made by Thomaskutty and George (2009) that Mathematics means different things to many people. According to him, "to many students, it is one of the obstacles that must be overcome to obtain a degree, to most undergraduates, it is a subject they wish they had studied more diligently; while to others, it is a constantly used concise language that makes exact and logical statements easier to form; a logical development made up of undefined terms, principles of logic, hypotheses and conclusion''. In a similar vein, Rees (1965) submitted that the Mathematicians conceptualized Mathematics as a pleasant way of living.

Hypotheses two and three were tested using Analysis of Variance (ANOVA). The findings in hypothesis two show that education level of the undergraduates had no influence on their conceptions of the aesthetic values of Mathematics. This affirmed the submission of Thomaskutty and George (2009) that individual differences in human beings could affect their perception of events, situations, or things, while faculty of the undergraduates had influence on their conceptions of the aesthetic values of Mathematics. Hypothesis two was accepted while hypothesis three was rejected.

CONCLUSION

The findings of the study revealed that undergraduates of University of Ilorin at a particular stage of their educational pursuit had studied Mathematics as a compulsory subject and may still be studying it either as a career or a required course for graduation in their chosen career at the University level. This serves as the background knowledge for those of them admitted to study it as career or a required course for graduation in their chosen course at the university level. Based on this, the male and female undergraduates students involved in the study have differently demonstrated their understanding of the beauty or aesthetics of Mathematics in terms of its utility, cultural/ historical value, challenge to human reasoning, creative and inventive nature. It is assumed that students' understanding of the aesthetic values of Mathematics would enhance learning process and performance in the subject.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

All learners of Mathematics particularly at the elementary level of education should be adequately engaged in all aspects of the activities of Mathematics such as in doing, criticizing, passing judgment and exposure to the historical/cultural place of Mathematics, as a way of providing aesthetic experience of Mathematics to learners.

The aesthetic values of Mathematics should be made an important component of Mathematics education curricula by curriculum developers because it is assumed that the understanding and knowledge of the aesthetics of Mathematics by teachers would serve as a motivator, a challenge to be creative, innovative and inventive for the students.

The aesthetic appreciation of Mathematics can be developed in learners through teacher's

pragmatic approach to teaching topics in Mathematics to enhance the reality and usefulness of the subject to daily activities.

There should be training and retraining programmes for Mathematics teachers at all levels of education on the relevance of aesthetic values of Mathematics and how the knowledge can be imparted through seminars, workshops, and conferences.

In the University academic programme, a course on the nature and history of Mathematics is required to assist in the understanding and the appreciation of the aesthetic values of Mathematics.

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