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Categorical Analysis of Impact of ND Mathematics Courses on Students Performance in Some Federal Polytechnics

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Abstract: *The world is speedily becoming a global village and that makes it even more imperative that individuals have a better understanding and appreciation of mathematical procedures and methods of reasoning to be carried along.Mathematical knowledge indeed equips individuals with the skill to solve a wide range of practical tasks and problems they may encounter in life.This research work focused on assessing Impact ofMathematicscourses though at National Diploma in Federal Polytechnics of North Eastern state of Nigeria. Samples of Students from four (4) Federal Polytechnics were drawn and information on the subject matter were collected using questionnaires. The data collected were analyzed using Chi-square test. The output of the analysis indicates that all the Polytechnic are doing well in relation to students' performance in ND Mathematics courses. Findingsof the analysis may serve as search light to stakeholders to determine the level of Students performance in ND Mathematics examinations in our various Institutions.Appropriate recommendations were made based on the result of the research.*

Keywords: *Categorical Data Analysis,Chi-square Test, ND Mathematics Courses and Students Performance*

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I. Introduction

The significance of mathematics in producing versatile and resourceful graduates that are needed for economic development cannot be over-emphasized. For this reason, the Science Teachers Association of Nigeria (1992) referred to mathematics as the central intellectual discipline of the Technology and Societies. (Mamman and Eya, 2014). Mathematics is vital to our days to day natural activities. There is nothing an individual would do in a day that would not have the application of some mathematical concepts. Mathematics is therefore a subject that supports all the science. No nation can hope to advance higher in Science and Technology without proper foundation in Secondary School Mathematics.

Mathematical knowledge indeed equips individuals with the skill to solve a wide range of practical tasks and problems they may encounter in life.Adeoti (2012) stated that knowledge of mathematics promotes the habit of accuracy, logical, systematic and orderly arrangements of facts in the individual learner. It also, encourages the habit of self-reliance and assists learners to think and solve their problems themselves.

Mathematics is to a nation what protein is to a young human organism. As a vital tool for the understanding and application of science and technology, the subject plays the necessary role of a precursor and premonition to the much needed technological and natural development of the developing nations of the world (Zalmon, and Wonu, 2017). Consequently, students are being encouraged to take up science and technology related disciplines. Globally today, scientific methods persuade literally field of human endeavour and play a fundamental role in economic development of any country (Obioma, 2009; NERDC, 2007). Mathematics is the language of science and engineering - describing our understanding of all that we observe. As a subject, it affects all aspects like social, economic, political, geographical, scientific and technological aspects in different degrees. Mathematics expresses itself everywhere in every facet of life - in nature all around us, and in the technologies in our hands. The interrelationshipbetween mathematics, development and advancement of humans shows how this subject is important in life for its numeral and symbolic behaviors, it is more related to the scientific and technological facets of man's world than to any other aspect as it occurs and reoccurs in the physical and natural sciences. It can be realized that the basic skills underlying entire technological skills are the control of the mathematical tools.Salehdeen and Murtala (2004), Compared "the relationship between admission grades and performance of students in the first professional examination in a new medical School" and also another study conducted independently by Oyebola (2006).

Mathematics is a fundamental segment of human thought and logic, and integral to attempts at mutual comprehending the universe and ourselves. Mathematics provides a prolific way of building mental discipline and encourages scientific reasoning and mental hardship.Mathematics is also a body of knowledge essential for the achievement of a scientific/technological nation.Ale and Adetula (2010) stated that the line of demarcation between the developed and underdeveloped nations is based on their level of mathematical attainment and

ingenuity.The importance of mathematics in national development is so high that the Federal Republic of Nigeria enshrined mathematics in the National Policy on Education as a core (compulsory) subject for all primary and secondary schools students in Nigeria (FRN, 2004). Its inclusion as a pre-requisite for admission into science and technology based courses in the Nigerian tertiary institutions is basically because of the recognition of the indispensable role it plays in the advancement of Science and Technology of any nation (Iyekekpolor&Bulus, 2009).The study of mathematics in ND programme is particularly of great importance because Polytechnic education is Science and Technology oriented. The minimum requirement for securing admission into any ND programmes in Nigeria Polytechnics is five passes at credit level in SSCE, in relevant subject areas including Mathematics and English Language as recorded in (NBTE Curriculum 2004).According to Das and Das, (2014), mathematical skill is extremely important not only for the higher education aspiring section, but also success in several competitive examinations for jobs depend upon the basic understanding in mathematics. Students' poor performance in mathematics over the years has been attributed to the fact that the subject is difficult. In the same view, student's performance in mathematics tests has been observed to vary from person to person and from school to school. Students' mathematicalperformance has become a matter of great concern to all stakeholders such as: parents, teachers,schools and government as whole. This research work focused on assessing Impact of Mathematics courses though at National Diploma in Federal Polytechnics inNorth Eastern state of Nigeria based on the relevant responses extracted from the questionnaires.

II. Methodology

The research work adopted a method of evaluations by means of quantitative research designwhich was established in collecting relevant data necessary for this work from Federal Polytechnics of North Eastern (NE) geopolitical zone of Nigeria.The Zone covers close to one-third (280,419km^2) of Nigeria's land area (909,890km^2). It comprises six (6) states which include; Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe states. According to projections for 2011 by the National BureauofStatistics (NBS), these States have 13.5% (i.e. 23,558,674) of Nigeria's population which is put at 173,905,439.Additionally, the Zone shares international borders withthree countries:Republic of Cameroon to the East, Republic of Chad tothe NorthEastand Niger Republic to the North.

Four (4) Federal Polytechnicswere considered for the research work from thiszone which comprises Federal Polytechnic Bali, Federal Polytechnic Bauchi, Federal Polytechnic Mubi and Federal Polytechnic Damaturu. Two Departments were considered from School of Science and Technology (i.e. Computer Science and Statistics) in each of these Polytechnics. Results of ND I students were selected at random from these Department andcollected based on their GPAs in linear Algebra and Logic (MTH 111), Functions and Geometry (MTH 112), Descriptive Statistics I (STA 111) and Elementary Probability Theory (STA 112) for 2017/2018 academic session. The samples of size 30 was drawnfrom each of these Departments of the Polytechnics, using simple random sampling techniques.The average of the four GPAs of the four selected courses were taken and considered as their ND Mathematics grade point using grading system given in Table 1. The grade pointswerethen comparedusing descriptive and inferences statistical tools for easy identification of differences in the students' performance.

Table 1: Unified Polytechnic Grading systems

Fed. Poly Marks	*Unified Grading*	*GPA*
75 – 100	A	4.00
70 – 74	AB	3.50
65 – 69	B	3.25
60 – 64	BC	3.00
55 – 59	C	2.75
50 – 54	CD	2.50
45 – 49	D	2.25
40 – 44	E	2.00
0 – 39	F	0.00

Source: Unified Polytechnic Grading System

Chi-Square (χ^2) Distribution is a statistical tools for analyzing categorical data. The square of a standard normal variable is called a chi-square variate with 1 degree of freedom (df). Thus if X is a random variable following normal distribution with mean μ and standard deviation σ, then $(X-\mu)/\sigma$ is a standard normal variate. Therefore $\left(\frac{X-\mu}{\sigma}\right)^2$ is a chi-square (χ^2)variate with 1 *d.f.*If $X_1, X_2, \dots, X_\nu$ are ν independent random variables following normal distribution with mean $\mu_1, \mu_2, \dots, \mu_\nu$ and standard deviation $\sigma_1, \sigma_2, \dots, \sigma_\nu$ respectively then the variate

$$\chi^2 = \left(\frac{X_1-\mu_1}{\sigma_1}\right)^2 + \left(\frac{X_2-\mu_2}{\sigma_2}\right)^2 + \cdots + \left(\frac{X_\nu-\mu_\nu}{\sigma_\nu}\right)^2$$

$$= \sum_{i=1}^{\nu} \left(\frac{X_i - \mu_i}{\sigma_i}\right)^2$$

which is the sum of the square of ν independent standard normal variates, follows chi-square distribution with ν degrees freedom (*d.f.*). If χ^2 is a random variate following chi-square distribution with ν d.f. then its probability function is given by

$$f(\chi^2) = \frac{1}{2^{\nu/2}\Gamma(\nu/2)} e^{-\frac{\chi^2}{2}} (\chi^2)^{\frac{\chi^2}{2}-1}; \qquad 0 < \chi^2 < \infty$$

where$\Gamma\nu = (\nu - 1)!$ if ν is a positive integer and $\Gamma\nu = (\nu - 1)\Gamma(\nu - 1)!$, $\nu > 1$ in general. It has a number of applications, such as i) Chi-square test of goodness of fit. ii) χ^2- test for independence of attributes. iii) Use to test if the population has a specified value of the variance σ^2. iv) also to test the quality of several population proportions. (Gupta, 2011)

One interesting use of the chi-square distribution (χ^2) as stated above is to test the hypothesis that two criteria of classification, when applied to the same set of entities are independent. The classification according to two criteria of a set of entities can be represented by a table in which the *r* rows represent the levels of one criterion and the *c* column the level of the second criterion. This type of cross classification is popularly known as a *Contingency Table*.

The test of independence is conducted by putting the observed frequencies in the *rc* cells and calculate the expected frequencies using $e_{ij} = \frac{N_{i\cdot} \times N_{\cdot j}}{N_{\cdot\cdot}}$. Compute $\chi^2 = \sum_i^r \sum_j^c \frac{(O_{ij} - e_{ij})^2}{e_{ij}}$or $\chi^2 = \sum_i^r \sum_j^c \frac{O_{ij}{}^2}{e_{ij}} - N$ and compare the χ^2value with the critical value $\chi^2_{(r-1)(c-1),\alpha}$ or determines probability of χ^2. If $\chi^2 > \chi^2_{(r-1)(c-1),\alpha}$, reject the null hypothesis H_o or if the probability of χ^2 is less than α, reject the null hypothesisH_0 as well. The*(r – 1)(c – 1)* is the degree of freedom for the χ^2 for $r \times c$contingency table. (Gupta, 2011)

The chi-square test statistic defined above can be used only if the following conditions are satisfied

i. The total frequency N, should be reasonably large.
ii. The sample observations should be independent. This implies that no individual item should be included twice or more in the sample.
iii. The constraints on the cell frequencies, if any, should be linear (i.e., they should not involve square & higher power of the frequencies) such as $\sum O = \sum E = N$
iv. No theoretical frequency should be small. Preferably, each theoretical frequency should be larger than 10 but in any case not less than 5. If any theoretical frequency is less than 5 then we cannot apply χ^2-test as such.
v. The given distribution should not be replaced by relative frequencies or proportions but the data should be given in original unit.

A measure of degree of relationship, association or independence of classification in a contingency table is given by

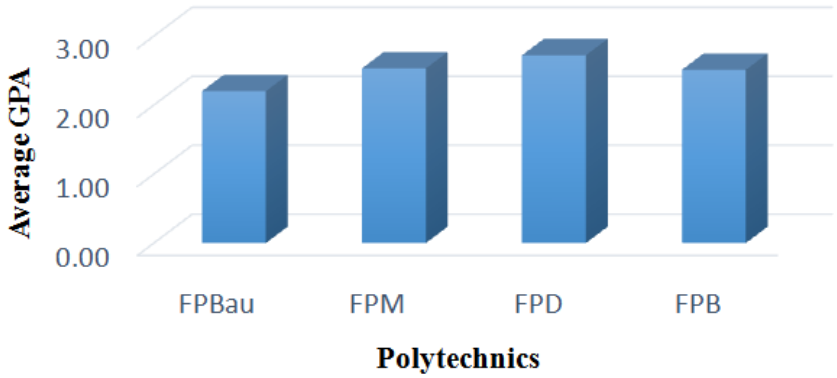
$$C = \sqrt{\frac{\chi^2}{\chi^2 + n}} \quad and \; n = rc$$

It is called the coefficient of contingency which is also employed in this analysis. The larger the value of *C* the greater is the degree of association between the two criteria of set of entities. The number of rows and column in the contingency table determines the maximum value of *C*, which is never greater than 1. If the number of rows and columns of a contingency table is equal to *k*, the maximum value of *C* is given by $\sqrt{(k-1)/k}$. (Gupta, 2011)

III. Data Analysis

Data collected were organized in tabular form and based on the underlie assumption,the formulas given above were adopted and the collected data was analyzed using Microsoft excel analysis tool. Simple bar chart was plotted for easycomparism of the students' performance from these Polytechnics and was presented in figure 1;

Fg. 1: Pie Chart potrayed the average performance of Students in ND Mathematics



The Figure 1; showsSimple Bar chart of the students' average grade points in ND Mathematics for the four Polytechnic under study. The bar indicates that Federal Polytechnic Damaturu has higher GPAs in their students' performance in ND Mathematics, followed byFederal Polytechnic Mubi. While Federal Polytechnic Bauchi shows low GPAs in their students' performance compare to other Polytechnics under study. Descriptive Statistics summary of the data were estimated and displayed inTable 2. The summary gives similar presentation of the Students' performance as the Bar chart, where Federal Polytechnic Damaturu has the highest average students' performance. Federal Polytechnic Mubi follows with lowest variability which indicated that, there is no much gap between students' with lowest performance and the one with highest performance in ND Mathematics. It also shows that the level of the students understanding of the courses is high when compare with other Polytechnics that has higher variance.

Table 2: Descriptive Statistics Summary for the Polytechnics under Study

Groups	***Count***	***Sum***	***Average***	***Variance***
FPBau	30	66.0625	2.2021	0.7583
FPM	30	75.875	2.5292	0.4684
FPD	30	81.625	2.7208	0.7373
FPB	30	75.3125	2.5104	0.6204

The test of significant used in the research work was based on the students' responses extracted from the questionnaires so far administered at 5% level of significant. The hypotheses involved are; H_0: Responses are independent of the Polytechnic (i.e. Classifications are independent) against H_1: Responses are not independent of the Polytechnic. The information analyzed are responses from the following questions asked in the questionnaire.

i. Did you like Mathematics subject in your secondary school? Yes ( ) No ( )
ii. If "No", why do you hate the subject?
iii. Rate your performance in Mathematics during your secondary school time.
iv. Rate your performance in Mathematics in the Polytechnic.

The data was then, further analyzed using Microsoft excel statisticalanalysis tools, where Chi (χ^2) square test techniques was employed after the expected frequencies were calculated from the observed frequency, the output and result were presented in Table 4, 6 and 8.

The students feeling toward Mathematics courses was asked and if the response is negative, "why do you hate the subject?" was then asked, with the following options "Not understanding the subject (*NU*), Natural hate (*NH*), Dislike teacher (*DT*), Peer group (*PG*) and Method of teaching (*MT*)". While *(NR)* represent Non Response from the respondents. Their responses were Tabulate in Table 3 below.

Table 3: Students' Responses on why they don't like Mathematics

Polytechnics	***NH***	***NU***	***DT***	***PG***	***MT***	***Total***	NR
FPBau	2	5	1	2	5	***15***	30
FPM	2	9	0	0	3	***14***	25
FPD	0	7	1	0	9	***17***	35

FPB	4	6	0	0	8	***18***	33
Total	***8***	***27***	***2***	***2***	***25***	***64***	

The expected frequencies were estimated by considering the total number of students responded to the question. Most of the student dislike the subject either because of not understanding the subject or method of teaching. If observed critically the method of teaching employed by some teachers or lecturers in either Secondary Schools or Polytechnic sector, respectively, has nothing interesting or enjoyable to offer to the learners. However, more than 60% of the students fail to respond to this question in the questionnaire.

Table 4: Expected frequencies on Students' Responses, why they hate Mathematics

Polytechnics	***NH***	***NU***	***DT***	***PG***	***MT***	***Total***
FPBau	1.88	6.33	0.47	0.47	5.86	15
FPM	1.75	5.91	0.44	0.44	5.47	14
FPD	2.13	7.17	0.53	0.53	6.64	17
FPB	2.25	7.59	0.56	0.56	7.03	18
Total	8	27	2	2	25	64

$$\text{Chi } (\chi^2)\text{square} = \sum_{ij=1}^{rc}\left[\frac{(O_{ij} - E_{ij})^2}{E_{ij}}\right] = 16.529$$

The analysis based on Chi (χ^2) square test shows that $\chi^2_{cal} = 16.529 < \chi^2_{(r-1)(c-1),\alpha} = 21.026$, hence we do not reject the null hypothesis and conclude that, the students' responses were independent of the Polytechnics at 5% level of significance. This indicates that some Students feelings toward ND Mathematics courses is irrespective of the Institution where they are studying, since more than 60% of the students have not responded. The output can be related to either effective method of impacting knowledge on the part of the lecturers concerned in the Polytechnic or the classroom organization and concentration on the part of the majority students.

The coefficient of contingency which was estimated as

$$C = \sqrt{\frac{\chi^2}{\chi^2 + n}} = \sqrt{\frac{16.529}{16.529 + 20}} = \sqrt{0.4525} = 0.6727$$

Show a high degree of association between the students' responses and the Polytechnic they come from.

Information was sought from students on how they can rate their performance in Secondary School Mathematics. The response was categorized as "*Excellent*", "*Very Good*", "*Good*", "*Fair*" and "*Poor*", to determine whether there is any positive impact of what they learn in Mathematics at the Polytechnics. The data collected were organized and presented in Table 5below.

Table 5: Observed frequencies on the Students Rating of their Mathematics Performance in Secondary Schools

Polytechnics	***Excellent***	***V.Good***	***Good***	***Fair***	***Poor***	***Total***
FPBau	4	13	21	6	1	***45***
FPM	6	15	10	6	2	***39***
FPD	4	23	21	4	0	***52***
FPB	7	21	17	4	2	***51***
Total	***21***	***72***	***69***	***20***	***5***	***187***

From Table 5 above, the expected frequencies on the Students' rating of their Mathematics performance in Secondary School were calculated using the procedure for conducting Chi-Square test. The estimated values were presented in the Table 6.

Table 6: Expected frequencies on the Students Rating of their Mathematics Performance in Secondary Schools

Polytechnics	***Excellent***	***V.Good***	***Good***	***Fair***	***Poor***	***Total***
FPBau	5.05	17.33	16.60	4.81	1.20	***45***
FPM	4.38	15.02	14.39	4.17	1.04	***39***
FPD	5.84	20.02	19.19	5.56	1.39	***52***
FPB	5.73	19.64	18.82	5.45	1.36	***51***
Total	***21***	***72***	***69***	***20***	***5***	***187***

$$\text{Chi } (\chi^2)\text{square} = \sum_{ij=1}^{rc} \left[\frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}} \right] = 10.671$$

The Chi (χ^2) square test techniques was employed to the data and the result shows that $\chi^2_{cal} = 10.671 < \chi^2_{(r-1)(c-1),\alpha} = 21.026$, hence we do not reject the null hypothesis and conclude that, the students' responses were independent of theirInstitution at 5% level of significance. This indicates that the Students ratingsof their performance is independent of their Institution.

The coefficient of contingency which was estimated as follows;

$$C = \sqrt{\frac{\chi^2}{\chi^2 + n}} = \sqrt{\frac{10.671}{10.671 + 20}} = \sqrt{0.3479} = 0.5898$$

Indicates that, there is a high degree of association between the students' ratings and the Polytechnic they come from.

Similarly, information was also extracted from students on how they rate their performance in ND Mathematics courses at the various Polytechnics. The response was categorized as "*Excellent*", "*Very Good*", "*Good*", "*Fair*" and "*Poor*" as well, to determine whether there is any meaningful impact of what they were thought in Mathematics at the Polytechnics. The data collected were organized and presented in Table 7 which shows more than 80% of the students rated their performance between "Good" and "Excellent". The corresponding expected frequencies were also calculated and presented in Table 8.

Table 7: Observed frequencies on the Students Rating of their Mathematics Performance in Polytechnics

Polytechnics	***Excellent***	***V.Good***	***Good***	***Fair***	***Poor***	***Total***
FPBau	9	18	16	2	0	***45***
FPM	10	13	15	1	0	***39***
FPD	8	25	19	0	0	***52***
FPB	11	22	16	1	1	***51***
Total	***38***	***78***	***66***	***4***	***1***	***187***

Table 8: Expected frequencies on the Students Rating of their Mathematics Performance in Polytechnics

Polytechnics	***Excellent***	***V.Good***	***Good***	***Fair***	***Poor***	***Total***
FPBau	9.14	18.77	15.88	0.96	0.24	***45***
FPM	7.93	16.27	13.76	0.83	0.21	***39***
FPD	10.57	21.69	18.35	1.11	0.28	***52***
FPB	10.36	21.27	18.00	1.09	0.27	***51***
Total	***38***	***78***	***66***	***4***	***1***	***187***

$$\text{Chi } (\chi^2)\text{square} = \sum_{ij=1}^{rc} \left[\frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}} \right] = 7.72$$

The result of analysis i.e. $\chi^2_{cal} = 7.72 < \chi^2_{(r-1)(c-1),\alpha} = 21.026$, which also shows that, the Students ratings of their performance in the Polytechnics is independent of their Institution. Hence we do not reject the null hypothesis and conclude that, the responses are independent of the Institution at 5% level of significance. This result of the analysis can be related to either effective method of impacting knowledge on the part of the lecturers concerned in the Polytechnic or the classroom management, organization and concentration on the part of the students was properly implemented. The coefficient of contingency for this response was also estimated as follows;

$$C = \sqrt{\frac{\chi^2}{\chi^2 + n}} = \sqrt{\frac{7.72}{7.72 + 20}} = \sqrt{0.2785} = 0.5277$$

The output indicates that, there is a slightly high degree of association between the students' ratings and the Polytechnic they come from.Note that, it is very difficult to say that all the lecturers taking mathematics courses in the Polytechnics has standard method of teaching. However, the stakeholders should encourage students and motivate the lecturers concern in achieving the goals of establishing the Polytechnics.

IV. Discussion

Having vastest organized andanalyzed the data using appropriate statistical tools,the researcher has further sought the views and comments of fifty two (52) students from each of these Polytechnics under studyusing simple questionnaire with closed end questions. Responses to some questions asked were presented in the Table 9 below with the corresponding number of questionnaires success returned from each of the Polytechnic.

Table 9: Some Responses of the Students interviewed using Questionnaire

	Did you offer any Mathematics course in the Polytechnic?			*Does the lesson taught in the Polytechnic improve your understanding of Mathematics?*	
	Yes	*No*		*Yes*	*No*
FPBau	45	0		42	3
FPM	39	1		40	0
FPD	52	0		50	2
FPB	49	2		49	2

More than 95% of the students responded positively and testified that, ND Mathematics courses have improved their understanding of Mathematics.Nevertheless, some trained Mathematics teachers and lecturers also display lack of knowledge of mathematics concepts which raises doubts about the process by which they acquired the certificates they possess. These problems has led to some factors that causes poor performance in mathematics as spelled out by AremuandSokan (2003) and Bakare(1994) that, the students' factors of poor academic performance were poor study habits, psychological adjustment problems, lack of interest in school programme, low retention, association with wrong peers, low achievement motivation and emotional problems.

Other studies, such as that of Salam (2004);Etsey (2005);Karande and Kulkarni (2005); Ong, Chandron, Lim, Chem and Poh (2010) &Ajayi and Ekundayo (2010) have shown that students' lack of financial support, absenteeism, truancy, use of local language in the classroom, lack of interest and joy in teachers' lessons and learning disability cause poor academic performance of students. Other causes include low cognitive ability, gender prematurity, medical problems and inability of students to understand examination questions.

V. Conclusion

In conclusion, Mathematics teachers ought to create interesting and non-threatening environments in their Mathematics classroom and model enthusiasm for the teaching and learning of the subject. This may go a long way to help students develop positive attitude towards the subject, learn it without any inhibition and hence improve their performance.

Aremu and Sokan (2003) and Bakre (1994) found out that the students' factors of poor academic performance were poor study habits, psychological adjustment problems, lack of interest in school programme, low retention, association with wrong peers, low achievement motivation and emotional problems. Oniemayin (1997) andOlajide (1998) separately expressed worries about the not-too-encouraging attitude of students which has been an impediment to their good academic performance in the country.

Government should improve the condition of service of Nigerian workers more especially teachers to make them comfortable and satisfied with their job.According to Sule (2009), instructional strategies in mathematics will improve if some of the problems plaguing the study of mathematics in Nigeria are solved.

Parents should play a vital role by visiting their children at schools frequently to know their situationand academic performance.

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