Fractality of global primary school dropout rates

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ABSTRACT

The significant number of dropouts of children from their primary education has directly contributed to a country's high percentage of illiteracy and the huge wastage of government funds. The present study looks into the prevalent causative factors of the dropout rates in the primary school education among nations. The method of fractal analysis helped probe deeper the exceptional cases that are still prevalent in some countries all over the world which serve as drivers of dropout rates in the primary level of education. Out of the 152 countries included in this study, at least seven of them cause its non-fractality. These countries that cause non-fractality indicate common and exceptional contributing factors in the primary education dropout rate phenomenon in the world. The use of fractal dimensions in investigating global primary school dropout rates showed that aside from the perennial factors that cause high dropout rates in the primary education level among countries i.e. economic, other prevalent causative factors come into play such as educational system, social status and social climate which nations all over the world must address if they are indeed serious to their commitment to the MDG on education. This fractality has showed that a significant number of dropout rates of children from their primary education have directly contributed to a country's high percentage of illiteracy and the huge wastage of government funds.

Keywords: dropout rate, fractal analysis, Millennium Development Goal, primary education

I. INTRODUCTION

Globally, it is an indisputable fact that the advancement of a nation mainly depends on the education of its citizens. Education always plays a vital role in the human and economic development of a nation and its people. The education goal of the Millennium Development Goal (MDG) 2015 is designed to ensure that every child in the world gets a primary school education. One of the challenges faced by this MDG education goal is the high dropout rates all over the world.

A huge number of literatures suggest the strong connection between primary school drop-out rates and the state of economy (Sabates, Westbrook, Akyeampong, & Hunt, 2010) as well as with other demographic factors present on a national scale (UNDP, 2010). UNESCO (1984) has cited some prevalent factors with regard to the increasing number of dropout rates in different countries. Though the contributing factors of high drop-out rates vary from country to country, but some factors that are prevalent in most countries include non-enrollment, socio-economic conditions, and the government's failure to prioritize education.

However, observations likewise point to the need to probe deeper into the phenomenon of dropout rates since exceptional cases are still prevalent. To determine such other causative factors that serve as drivers of dropouts at the primary level, the method of fractal analysis is deemed most appropriate. The substantial rates of primary school dropout across countries have kept children away from school without acquiring the most basic learning. The study then explores the fractality of global school dropout rates.

II. CONCEPTS IN FRACTAL ANALYS

Fractal analysis is used to conditions where short-range fluctuations dominate larger ones (Padua, & Borres, 2013). In fractal geometry, the notion of a

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fractal dimension (**λ**) is its central concept. Padua, Palompon & Ontoy (2012) proposed the use of a power law distribution. This power law distribution is similar to the power-law probability distribution of Pareto which is defined as:

1.... $f(x) = \left(\frac{\lambda - 1}{\theta}\right)\left(\frac{x}{\theta}\right)^{-\lambda}, \lambda > 1, \theta > 0, x > \theta$

In the fractal distribution, the exponent **λ** is referred to as the fractal dimension of X, and θ is the random variable's smallest (positive) value.

In order for each conversation to contribute to the fragmentation of the support X, the maximum likelihood estimator of **λ** is defined as:

2.... $\hat{\lambda} = 1 + \frac{1}{\log(\frac{x}{9})}$

Padua et al. (2013) suggested that in order for the mean and variance of the fractal dimensions to exist, the distribution of the maximum likelihood estimators follow an exponential type of distribution.

Table 1.
Percentage Primary School Dropout Rate of 152 Countries

Countries	%	Countries	%
1. Norway	0.5	77. Belize	9.7
2. United States	6.9	78. Fiji	9.1
3. Germany	4.4	79. Jordan	6.6
4. Sweden	1.0	80. Suriname	9.7
5. Korea (Republic of)	1.2	81. El Salvador	13.5
6. Hong Kong, China (SAR)	0.5	82. Bolivia (Plurinational State of)	16.3
7. Iceland	2.5	83. Mongolia	5.9
8. Denmark	0.5	84. Occupied Palestinian Territory	1.5
9. Israel	1.1	85. Paraguay	21.9
10. Belgium	6.6	86. Moldova (Republic of)	4.8
11. Austria	2.3	87. Philippines	24.2
12. Singapore	0.9	88. Uzbekistan	1.9
13. Finland	0.5	89. Syrian Arab Republic	5.4
14. Slovenia	0.5	90. Guyana	16.5
15. Spain	0.5	91. Botswana	13.2
16. Liechtenstein	18.2	92. Honduras	23.8
17. Italy	0.3	93. Indonesia	20.0
18. Czech Republic	0.4	94. Kiribati	21.1
19. Greece	2.6	95. South Africa	23.0
20. Brunei Darussalam	3.9	96. Vanuatu	28.5
21. Cyprus	4.7	97. Kyrgyzstan	2.4
22. Malta	20.3	98. Tajikistan	1.1
23. Estonia	1.6	99. Viet Nam	7.9
24. Slovakia	2.3	100. Namibia	17.4
25. Qatar	6.4	101. Nicaragua	51.6
26. Hungary	2.3	102. Morocco	9.5
27. Barbados	4.2	103. Iraq	33.3
28. Poland	2.4	104. Cape Verde	14.3
29. Chile	2.6	105. Guatemala	35.2
30. Lithuania	1.6	106. Timor-Leste	33.4
31. United Arab Emirates	3.3	107. Ghana	27.8
32. Latvia	5.4	108. Equatorial Guinea	38.1
33. Argentina	6.2	109. India	34.2
34. Seychelles	15.1	110. Cambodia	45.5
35. Croatia	1.0	111. Lao People's Democratic Republic	33.0
36. Bahrain	1.8	112. Bhutan	9.0
37. Bahamas	10.5	113. Swaziland	16.1
38. Belarus	0.3	114. Congo	29.7
39. Uruguay	4.8	115. Sao Tome and Principe	32.0
40. Kuwait	4.0	116. Kenya	27.2
41. Russian Federation	3.9	117. Bangladesh	33.8
42. Romania	4.9	118. Pakistan	38.5
43. Bulgaria	6.2	119. Angola	68.1
44. Saudi Arabia	6.7	120. Myanmar	25.2
45. Cuba	3.8	121. Cameroon	33.8
46. Panama	6.2	122. Madagascar	65.4
47. Mexico	6.0	123. Tanzania (United Republic of)	18.6
48. Costa Rica	11.2	124. Nigeria	20.1
49. Malaysia	2.3	125. Senegal	40.4
50. Serbia	1.4	126. Mauritania	29.3
51. Trinidad and Tobago	10.6	127. Nepal	38.3
52. Kazakhstan	0.2	128. Lesotho	30.7
53. Albania	4.8	129. Togo	40.6
54. Venezuela (Bolivarian Republic of)	7.9	130. Yemen	40.5
55. Dominica	11.9	131. Uganda	68.2
56. Georgia	3.8	132. Zambia	46.9
57. Lebanon	8.2	133. Djibouti	35.7
58. Saint Kitts and Nevis	26.5	134. Gambia	38.9
59. Iran (Islamic Republic of)	5.7	135. Benin	35.7
60. The former Yugoslav Republic of Macedonia	2.5	136. Rwanda	63.0
61. Ukraine	2.3	137. Côte d'Ivoire	39.2
62. Mauritius	2.2	138. Comoros	25.9
63. Bosnia and Herzegovina	26.8	139. Malawi	47.2
64. Azerbaijan	3.6	140. Sudan	9.1
65. Oman	2.7	141. Ethiopia	52.5
66. Brazil	24.3	142. Liberia	54.4
67. Jamaica	4.8	143. Burundi	43.8
68. Armenia	2.3	144. Guinea	34.3
69. Saint Lucia	7.9	145. Central African Republic	53.1
70. Ecuador	19.4	146. Eritrea	31.0
71. Turkey	8.2	147. Mali	24.5
72. Colombia	15.5	148. Burkina Faso	36.4
73. Sri Lanka	1.4	149. Chad	76.7

Moreover, Padua and Borres (2012) suggested fractal spectrum as a device used to identify the locations of the support X where high data roughness or fragmentation occur and where smoothness appear to dominate. The spectrum is defined as:

3.... $\lambda(s) = 1 - \frac{\log(1-a)}{\log(\frac{x}{9})} = 1 - \frac{\log(1-a)}{x} \quad s = \log(\frac{x}{9})$

where X_α is the αth percentile of X and .

III. METHODOLOGY OR THEORY VALIDATION

The study used descriptive research design. The data were gathered from the World Bank statistics on the dropout rates of primary education schools among 152 countries for the year 2002-2011. The data were readily available from the Internet.

The data were arranged as an Excel file according to the country with the lowest incidence of dropout rates in primary education down to the country with the highest. The data were then analyzed using fractal statistical software (Fractal Software) to determine

whether the data have fractal dimensions. The analyzed data were then exported to the fractal software which then yielded exponential dimensions of the variables to be probed. The Ryan- Joiner Test was then made to determine if there was a normal distribution with the data set and to determine exponential dimensions. Ryan-Joiner Test was used in this study as it was a simpler alternative to the Shapiro-Wilk Test. The correlation coefficient of Ryan Joiner statistical test is:

$$Rp = \frac{\sum_{i=1}^{n} e_{(i)} z_{(i)}}{\sqrt{s^2 (n-1) \sum_{i=1}^{n} z_{(i)}^2}}$$

where the $z(i)$ values are the z-score values of the corresponding $e(i)$ value, and $s2$ is the sample variance. An indication that there is a normal distribution of errors was when the values of Rp is closer to 1. The exponential dimensions represented the degree to which the variables fragment a smooth straight line. The exponential dimensions now represented the ruggedness or roughness of the figures representing the countries' dropout rates from 2002-2011.

IV. Results and Discussion

Table 1 shows that the list of 152 countries with their corresponding primary school dropout rate from the year 2002-2011.

After testing the data using fractal statistical software (Fractal Software), the histogram indicated exponential dimensions. Thus, the hypothesis of exponentiality was confirmed by the Ryan- Joiner test made. This pattern of exponentiality was illustrated in *Figure 1* with the histogram of the percentage Primary School Dropout Rate of 152 Countries.

The second histogram found in Figure 2, which was the exponential dimensions of the drop-out rate in Figure 1, appeared to have fractal distribution.

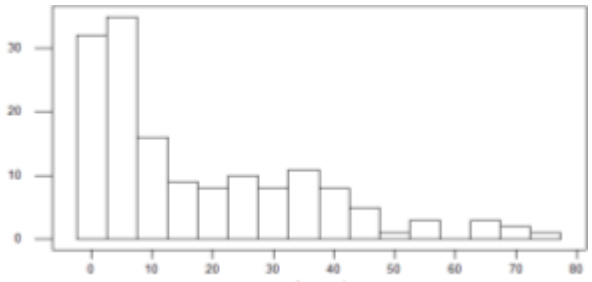

Figure 1. Histogram of the Percentage Primary School Dropout Rates of 152 Countries

However, it has been observed that out of the 152 countries included in the study, at least seven countries have caused non-fractality. The seven countries in the graph that caused the non-fractality were Chad, Uganda, Angola, Madagascar, Mozambique, Rwanda and Liberia. These countries have had characteristics that made them distinct. Interestingly, these countries implied common characteristics with regard to their geographical locations; all the six nations are found in the African region. All these seven countries belong to Sub-Saharan Africa, the area in the African continent which is found south of the Sahara.

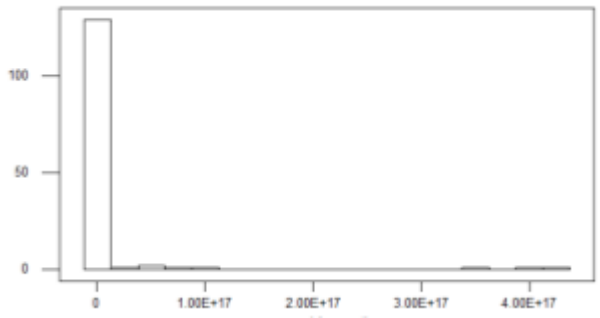

Figure 2. Histogram of the exponential dimension of Global primary school drop-out rate

Global Dropout Rates Model. This Global Droupout Rates Model described the hidden aspects in the fractal phenomenon. It was the result of the prevalent factors of the primary school dropouts present among the seven (7) African countries that caused non-fractality compared to the rest of the 145 countries. Some of these prevalent factors aside from the most common among most countries (economic climate) are the country's educational system, social climate and social status.

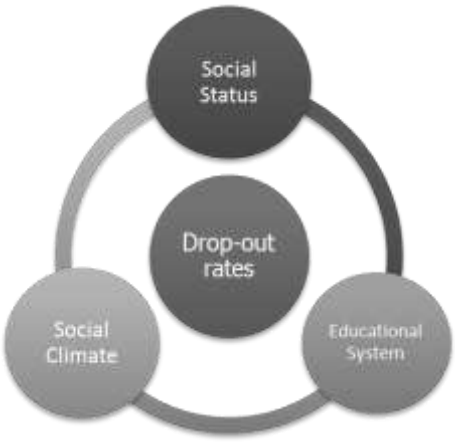

Figure 3. Global Dropout Rates Model

Educational System. Watkins (2013) had observed that a decade ago, some African nations such as Ethiopia, Kenya, Mozambique, Senegal, Tanzania, and

Zambia were far behind in terms of the number of enrolment. At present, these African nations have slowly shifted towards the right direction. This improvement in the educational condition of these African states were primarily because of the reforms instituted by their governments which include the removal of school fees, allotment of substantial budget for school infrastructure, and the recruitment of more teachers. However, African countries have been experiencing challenges in the education of primary school-age children with at last 30 million of them who are still out of school. This was one reason why access to universal education has slowed down in the past years. This was the first factor in the seven countries that caused the non-fractality of the phenomenon.

It cannot be denied that there has been learning crisis, and the heart of this crisis was at teaching. The problem on the level of the teacher's professional competence to teach on specific subject areas would explain why so many kids learn so little. Watkins (cited by Veras, 2016) revealed that several studies have found that fewer than 50 percent of teachers in Lesotho, Mozambique, Uganda and in other African countries could get a passing score on a test designed for 12 year-old students.

Furthermore, teacher absenteeism had high epidemic levels in such countries. But blaming the Africa's teachers for the learning crisis would miss the point. These teachers were also the product of the same flawed educational system. In the process, they were just passing on to their students what they have learned from the educational system in which they now operate.

It has been observed that educational objectives, which included the expected learning outcomes of the pupils, were some of the frequently lacking detailed information in their operation. These African primary school teachers were barely given support and guidance from their senior colleagues and administrators on effective teaching strategies. As a result, these teachers have still employed the outmoded teaching strategies and instructional materials.

Plus in extremely harsh condition, they have often been working for insufficiency-level wages. The level of teachers' salary had a high impact on the educational systems performance (Jarousse, 2009). Mingat (2004) had identified at least two factors that have influenced a teacher's salary vis-à-vis educational performance, namely: quantity and equity. The study argued that if teachers were paid higher salary, there would be a big possibility that massive teacher recruitment, which has been the case among African countries as of the present, can be averted. As a result, completion rates among primary school pupils would increase as a result of higher salary rates for teachers since primary school repetition rate would be lessened and more funds could be poured in improving educational resources.

Educational policies had also multiple factors. The primary concern in the educational policies among the states of Angola, Chad, Liberia, Madagascar, Mozambique, Rwanda, and Uganda was the pupil-teacher ratio. Jarousse et al. (2009) have observed that there was very little improvement as far as pupil-teacher ratio was concerned in Africa in the last fifteen years. The condition of classroom overcrowding was also widespread among these countries.

In Rwanda, childrearing and the education of the children was the mother's duty. However, the children's formal education was the responsibility of the state. Rwada has been operating under a 6-3-3-4 educational system: six years for primary school; three years for secondary school; three years for senior secondary school; and for a bachelor's degree.

However, only about 60 percent of Rwanda's children have attended school. Of this 60 percent, only less than 10 percent attended high school. For most Rwandans, even a small amount of school fees was something that the people could barely afford. Higher education was also something that the state had put little emphasis of among its people. Only a very small portion of Rwandans continued on to university.

In Liberia, children were expected to be potential workers and took on chores at an early age. This has discouraged children from going to school for they were always viewed to be supporters of their parents in old age. Liberia had also very limited access to higher education.

On the other hand, Madagascar followed a policy wherein education was compulsory for children aged 6 to 14. However, this policy was hardly followed in remote areas where children were expected to help their parents in the household chores and agricultural work. The 1972 uprising had resulted to educational reform in Madagascar which has gradually improved the educational system in the country especially in higher education. In spite of this improvement in education, access in higher education has still been limited primarily due to the decline in national spending.

Gender inequality in education was one the primary issues hounding Uganda. Of the 62 percent literate Ugandans, only a handful of them were women while almost three-quarters were men. Opportunities for

higher education among the people of Uganda were very limited considering that most higher education institutions largely depended on international organizations and private companies. However, on a positive note most of Ugandans held higher education as an important factor for national development.

Social Climate. Another factor that hindered the progress of the seven countries was conflict. As a result of political upheavals and militarization including arm uprising, children who have been living in conflict-ridden areas were not spared from the atrocities that befell their countries. As a consequence, children stopped attending schools and along with their families, they have been displaced from their homes. After how many years, over one million children were still out of school.

In Liberia, for example, armed fighters as young as nine years-old perpetrated random massacres in villages. These young fighters were employed by local warlords. Despite the reestablishment of Liberian legal institutions in 1997, civil rights abuses were still rampant in the country.

In Rwanda, ethnic conflict in 1994 between the Hutu government and the Rwandan Patriotic Front claimed thousands of lives of Rwandans. As a result, Harroy (cited by Batware, 2012) argued that this conflict has caused inequality in education wherein a certain ethic group was favored than the other. Tutsis were given priority in education and employment than the Hutus. This condition in the educational sector of Rwanda has left millions of children with no access to basic education. However, Batware (2012) contended that only demilitarization can pave the way for the formation of a new Rwandan government that was acceptable to both ethnic groups.

Inequality in the access of primary school education has also been the problem faced by millions of people from Madagascar (Glick et al., 2005). For almost a decade or from 2001-2008, the UNICEF (2015) has seen the progress in the enrollment and quality education in the primary school level in Madagascar. However, the 2009 political crisis affected the educational system in Madagascar with the suspension of support and funding from various international organizations. The quality of education in Madagascar has deteriorated due to various factors which include rising public school fees, poor economic planning, and dismal allocation of budget for basic education (UNICEF, 2015; Glick et al., 2015).

The other countries included in this study which caused the non-fractality in the global primary school dropout rates have had the same problem with Liberia, Rwanda and Madagascar. The various armed-conflicts including the civil war from 2005-2010 in Chad had affected the education sector in the country (Collelo as cited by UNESCO, 2011). Access to basic education among the poor was also a problem in Chad primarily due to the small budget allocation in education. In Uganda, the last two decades have created an unsecure environment for children which hindered their access to primary school education. The war of the government of Uganda against the rebel group Lord's Resistance Army has paralyzed the schooling of children in the country. It has affected the people living in the northern part of Uganda. Although pupils can still attend school; however, there was scarcity in terms of instructional materials, educational facilities and teachers. This situation in the northern part of Chad has been considered as humanitarian catastrophe as children were kidnapped and used as sex slaves (Finnstrom as cited by UNESCO, 2011).

In Mozambique, the destruction of various school infrastructures and economic crises as a result of civil war as well as the many natural calamities that hit the country had negative effects on its educational sector where access to primary education has been limited (UNESCO, 2011). In Angola, the civil war which erupted right after the country's independence from Portugal and which lasted for almost three decades has greatly affected the educational system in the country where the education of school-age children was hampered primarily due to the insecure environment.

Social Status. The African countries of Chad, Uganda, Angola, Madagascar, Mozambique, Rwanda and Liberia have been plagued with inequalities in education particularly in the primary school level. These inequalities were a result of the many discrepancies in their educational system. In Mozambique, children who belonged to poor families wwould likely end up to be part of the lowest 10 percent of the student population (Watkins, 2013). There was a need for urgent genuine reforms in the educational system in the African region. Lethal interactions between poverty, inequality and educational disadvantage have been a problem that began long before children enter school.

Another factor that affected preschool learning of these countries was parental illiteracy. This was part of the factors for social status. Over the past decade, almost 50 million school-age children had come from families whose parents could not read and write. As a result, parents could not support the academic needs of their children such as project, homework and the likes. The struggles of these children were mostly attributive to the transition period from home to

school. Most of the children in Chad, Uganda, Angola, Madagascar, Mozambique, Rwanda and Liberia lack the basic literacy skills (numeracy, reading and language) which they needed before entering primary education.

The social and economic environments can inevitably affect the educational systems in Africa which they operate. Many out of school children sought employment due to household poverty. In countries such as Niger, Chad and Mali, child marriage has been recorded as the highest levels in the world. What makes it worse was that female children in these African states have become brides prior to completing their primary education. Children's education has also been affected by existing inequalities particularly gender and ethnicity. Gender disparities were common in armed-conflict areas where violence against female pupils was rampant. This prompted parents not to send their children to school amidst the incidence of kidnapping which was common among female children (Shemyakina, 2006; UNESCO, 2011).

V. Conclusion

The use of fractal dimensions in investigating global primary school dropout rates showed that aside from the perennial factors that have caused high dropout rates in the primary education level among countries i.e. economic, other prevalent causative factors came into play such as educational system, social status and social climate which nations all over the world must address if they are indeed serious to their commitment to the MDG on education. This fractality has showed that a significant number of dropout rates of children from their primary education have directly contributed to a country's high percentage of illiteracy and the huge wastage of government funds.

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