Computational Analysis of Average Waiting and Arrival Times

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Abstract: Over the years, the drift from public to private schools has overwhelmed parents' and guardians' imagination due to teachers' and pupils' waiting times and the influence of parents in private and public schools. The government has also slowed parental emotions to send their children to public schools due to the lack of basic teaching tools, well-trained teachers, and vital infrastructure in many states in Nigeria. As a result, private individuals with inadequate educational management backgrounds started establishing schools as a business concern without proper regulations on teachers' recruitment, vital and basic school facilities. The proliferation of substandard private and public schools has led to waiting time problems. This article describes novel computational procedures to compute the average waiting and arrival time. The procedures investigate teachers and pupils' average arrival and waiting times for public and private primary schools in each class in a local government area in Delta State, Nigeria. A simple random sampling procedure was applied. The study intends to determine whether the mean waiting or arrival time of teachers and pupils for each class for the period under review is equal. The data set was subjected to further mean analysis and analysis of variance. The F statistic was obtained and compared with the F critical value, which resulted in the rejection of the null hypothesis at a 5% level of significance. The analysis indicated that the average waiting time for teachers' arrival in each class is not equal and the average waiting time for pupils' arrival is not equal, hence the null hypothesis's rejection. The study revealed that the average waiting time for public and private school pupils in the schools investigated is 17 minutes. In comparison, the average waiting time of teachers for both public and private schools is approximately 6 minutes. This study affirmed that waiting time problems exist in public and private schools.

Keywords: classification, benchmark, waiting time, arrival time.

平均等待和到达时间的计算分析

摘要：多年来，由于教师和学生的等待时间以及家长在私立和公立学校的影响，从公立学校转向私立学校的趋势已经超出了家长和监护人的想象。由于尼日利亚许多州缺乏基本的教学工具、训练有素的教师和重要的基础设施，政府还减缓了父母将孩子送到公立学校的情绪。结果，教育管理背景不足的个人开始将学校作为企业经营，而对教师招聘、重要和基本的学校设施没有适当的规定。不合标准的私立和公立学校的激增导致了等待时间问题。本文介绍了计算平均等待和到达时间的新颖计算程序。该程序调查了尼日利亚三角州地方政府区域每个班级公立和私立小学的教师和学生的平均到达和等待时间。应用了一个简单的随机抽样程序。该研究旨在确定审查期间每个班级的教师和学生的平均等待或到达时间是否相等。

对数据集进行进一步的均值分析和方差分析。获得 F 统计量并与 F 临界值进行比较，这导致在 5% 的显着性水平上拒绝原假设。分析表明，每个班级教师到校的平均等待时间不相等，学生到校的平均等待时间也不相等，因此拒绝原假设。研究显示，在所调查的学校中，公立和私立学校学生的平均轮候时间为 17 分钟。相比之下，公立和私立学校的教师平均轮候时间约为 6 分钟。这项研究肯定了公立和私立学校都存在等待时间问题。

关键词：分类、基准、等待时间、到达时间。

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1. Introduction

Research has shown that the early arrival of pupils at school has many advantages. The US national center for education statistics discussed the average start time for some selected schools [1]. The average time for school to start learning activities is 7:59 a.m. daily on school days. This implies that parents and pupils must wake up early to prepare, which indirectly alters the biological sleeping patterns of parents and pupils [2]. Average waiting time concerning response to oral classroom questions has been studied [3-4].

Waiting time in the health sector has been investigated in detail [5]. The average waiting time for a patient to consult the doctor was investigated based on a universal sampling technique, and the arrival time was recorded using a queue management system. It has been stressed that waiting time is vital in any service-related sector [6-7]. However, different factors play a significant role in explaining average waiting time, which depends on the availability of facilities, workforce, policy, and country [8-9]. Studies on waiting times in the fast-food service sector in Bangladesh have gained recognition [10-11].

It is a general conception that teachers in recent times, particularly public-school teachers in Nigeria, often report late to duty posts. Based on this and other learning reasons, some parents decide to enroll their children in private schools in order for the kids to get adequate attention from teachers. This claim has made some parents more interested in enrolling their kids in private schools. This study aims to determine the validity of the claims that private school teachers are punctual and resume earlier than public school teachers. In addition, this discussion investigates whether the above "conception" is policy- or location-dependent [12-13].

There are insufficient or no available articles on determining the average waiting time of teachers and pupils in the public domain. However, the following are some of the positive outcomes of this study:

a. Giving confidence to parents whose children are in public and private schools based on the current trend;

b. Availing the school administrators and ministry of basic education, Delta State, Nigeria, to monitor the activities of teachers in public and private primary schools across the state;

c. Motivating the teachers to resume their duty post at the appropriate time;

d. Introduction of an electronic attendance register for teachers.

To achieve the outcomes, we present a novel procedure to compute average arrival and waiting time, and the mean approach embedded in the analysis of variance (ANOVA) was applied.

The rest of the paper is organized as follows. In Section 2, we discuss the proposed methods of average waiting and arrival times, the analysis of variance, and data collection. Then, Section 3 is devoted to results and discussion, and the conclusion is presented in Section 4. Finally, the limitation is presented in Section 5.

2. Methods

2.1. The Average Waiting and Arrival Method

This subsection contains the computational procedure for the following:

i. Average arrival time (AAT);
ii. Average waiting time (AWT).

The average arrival time is

$$AAT_{arrived} = \frac{\left| \sum_{i=1}^{2} (AT_0 - \emptyset_i) \right|}{2}, \qquad (1)$$

where AT_0 is the time benchmark, and ø is the arrival time. The formula to compute the average waiting time is

$$AWT_{waiting} = \frac{\left| \sum_{i=1}^{2} (AT_i - \emptyset) \right|}{2}. \qquad (2)$$

The above procedures look simple in terms of computational procedures, but caution must be exercised to avoid computational error during data conversion.

2.2. Analysis of Variance (ANOVA)

The analysis of variance (ANOVA) is a tool to analyze the relationship between independent and dependent variables when the group means are compared for equality [14-15]. The concept of ANOVA relies on the F-test to make inferences. It is a parametric procedure applied to analyze data sets from

an experiment. ANOVA is considered the most efficient technique to analyze experimental data [16]. ANOVA has been applied to different research fields, including mining, nursing science, agricultural information, brain network, safety studies, and security indexes [17-21].

The basic analysis of the variance model [22] can be expressed as follows

$$x_{nm} - \mu + \pi_n + \varepsilon_{nm}$$

where the subscript n denotes observations and m treatment. The observed values are assumed to be normally distributed, $X_{nm} \sim N(\mu, \sigma^2)$. This model consists of the following: the mean μ, treatment π_n, and the error term ε_{nm}, which is a random observation drawn from the normal distribution $N(\mu, \sigma^2)$. The error term indicates the difference between the error of measurement and replication. The above model can be written as follows:

$$x_{nm} = \mu + \pi_n + \varepsilon_{nm.}$$

This clearly states that x_{nm} consists of the three parameters and, as such, is normally distributed. The variance analysis relevance to this study depends on the F-test to determine whether the hypothesis is significant or not. Presenting this analysis in this way, we state the mean square due to treatment (MSTR)

over the mean square due to error (MSE) to express the F test, that is

$$F = \frac{MSTR}{MSE}$$

where $MSTR = SSTR/(N-1)$, and the sum of square due to treatment (SSTR) is

$$SSTR = \sum_{i=1}^{N} N_i (\bar{x}_i - \bar{\bar{x}})^2,$$

where $\bar{x}_i = \frac{\sum_{j=1}^{n} x_j}{n}$ and $\bar{\bar{x}} = \frac{\sum_{i=1}^{m} \bar{x}_i}{m}$ are the embedded sample and grand means, respectively. The mean square due to error (MSE) is given as

$$MSE = \frac{SSE}{N_T - N}.$$

The sum of square due to error (SSE) is stated as

$$SSE = \sum_{i=1}^{N} (N_i - 1) S_i^2,$$

The SSE has an F-distribution with $N-1$ and N_T-N degrees of freedom (df). If the null hypothesis is true, the MSTR is unbiased to the population variance. The contrary implies that MSTR will overestimate the variance. In general, suppose H_0 is true, then the value of F=MSTR/MSE tends to have been chosen from the F-distribution [23]. Table 1 describes the analysis of the variance procedure.

Table 1 ANOVA procedure

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F
Between treatment	SSTR	N-1	$MSTR = \frac{SSTR}{N-1}$	$F = \frac{MSTR}{MSE}$
Error sum of square	SSE	N_T-N	$MSE = \frac{SSE}{N_T-N}$	
Total	SST = SSTR + SSE	N_T-1		

The null hypothesis H_0 determines whether pupils' and teachers' average arrival and waiting times are equal. The alternate hypothesis H_1 shows that pupils' and teachers' mean arrival and waiting times are different.

2.3. Data Collection

Five investigators were assigned to public and private primary (P_i, i = 1,2,3,4,5 are classes) schools in Oshimili South local government area, Asaba, Delta State capital, Nigeria, to ascertain the arrival and waiting times by parents bringing their children to school between 6:45 a.m. and 8:00 a.m. for two weeks (February (last week) - March (first week) 2019). Each investigator was assigned to each class for the public and private classifications of schools. This study determines whether the pupils' average arrival and waiting times differ from the teacher's arrival and waiting times. The same data collection method was also carried out for teachers to determine the average arrival and waiting times of teachers before pupils' arrival. It was observed that two teachers were assigned to each class. If both teachers are in the class before the arrival of pupils, the waiting time in minutes will be

zero. If one of the teachers arrives before the other, the arrival time is divided by two. On the other hand, if the pupil arrives before both teachers, the arrival and waiting times will be recorded, and the average will be taken. The time benchmark before recording for this study is 6:45 a.m. For instance, if the two teachers arrived (AT_0) at 6:45 a.m., the time benchmark is equal to AT_0, and the computational formula is

$$AAT_{arrived} = \frac{\left|\sum_{i=1}^{2} AT_0 - \emptyset_i\right|}{2} = \frac{|(6:45 - 6:45) + (6:45 - 6:45)|}{2} = 0,$$

where $i = 1,2$ indicates the number of teachers in the class. On the other hand, if the pupil arrived (waiting) before the teacher's arrival, the formula for computing the average waiting time is:

$$AWT_{waiting} = \frac{\left|\sum_{i=1}^{2}(AT_i - \emptyset)\right|}{2}, \emptyset = 6:45.$$

For example, if a pupil arrived before the two teachers arrived at 7:06 a.m. and 7:12 a.m., respectively, the last expression can compute the waiting time in minutes.

$$AWT_{waiting} = \frac{\left|\sum_{i=1}^{2}(AT_i - \emptyset)\right|}{2} = \frac{|7:06 - 6.45| + |7:12 - 6.45|}{2} =$$

$$\frac{|(7 \times 60) + 06 - (6 \times 60) + 45| +}{|(7 \times 60) + 12 - (6 \times 60) + 45|}{2} =$$

$$\frac{|426 - 405| + |432 - 405|}{2} = \frac{|21 + 27|}{2} = \frac{|48|}{2} = 24.$$

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This implies that the first pupil who arrived would probably have waited an average time of 24 minutes before the teachers arrived. Equation (2) updates the weekly average waiting time for public and private school data sets.

3. Results and Discussion

3.1. Results Based on the Embedded Mean

Tables 2-5 reveal the comparative analysis of pupils' and teachers' mean arrival and waiting times in public and private primary schools for the first arrival. The analysis showed that the pupils wait longer than their teachers. In addition, the study showed that the public primary school pupils' average arrival and waiting times are longer than those of private primary school pupils. However, the waiting time of teachers in both public and private primary schools are approximately equal.

Table 2 Average arrival and waiting times of public primary school pupils

Weeks/Classes	P1	P2	P3	P4	P5
Week 1	28.2	27.6	9.0	8.2	11.6
Week 2	30	16.2	8.4	14.2	17.4

Table 3 Average arrival and waiting times of private primary school pupils

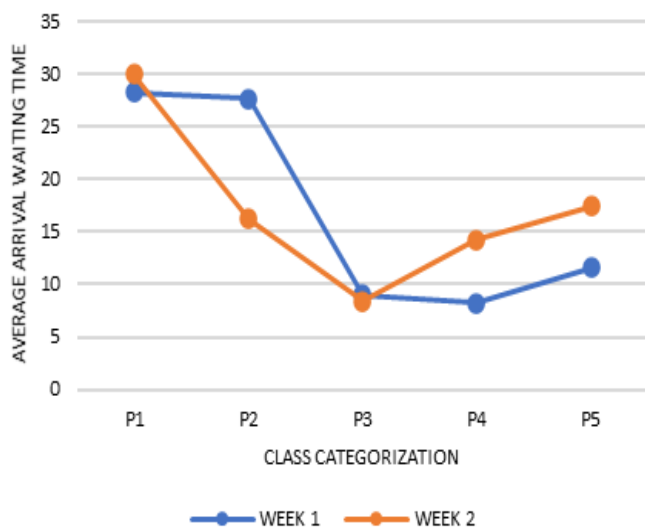| Weeks/Classes	P1	P2	P3	P4	P5
Week 1	12.2	26	8.8	18.6	20
Week 2	7.8	9.4	9.0	24	7.2

Fig. 1 Average arrival and waiting times for public primary school pupils
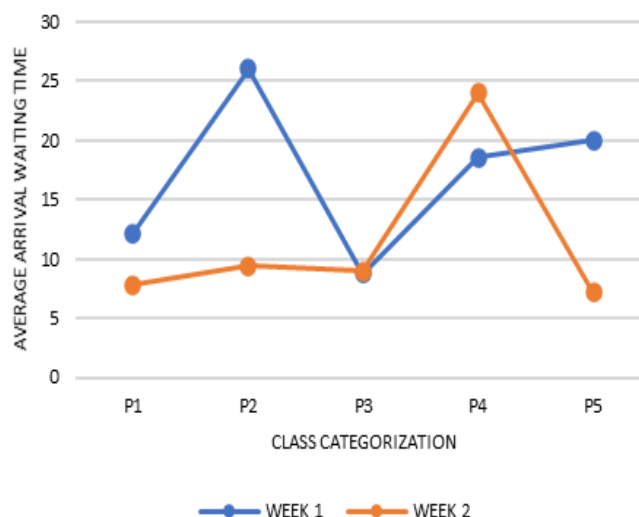

Fig. 2 Average arrival and waiting times for private primary school pupils

From Fig. 1 and 2, we observed that the rating of pupils' waiting time declined in the second week of the investigation compared to the first week for the public and private primary schools. However, it was observed that the waiting rate is longer for public schools than the private schools.

Table 4 Average arrival and waiting times of public primary school teachers

Weeks/Classes	P1	P2	P3	P4	P5
Week 1	4.2	14	6.8	3.0	3.4
Week 2	5.6	1.8	5.0	5.6	9.8

Table 5 Average arrival and waiting times of private primary school teachers

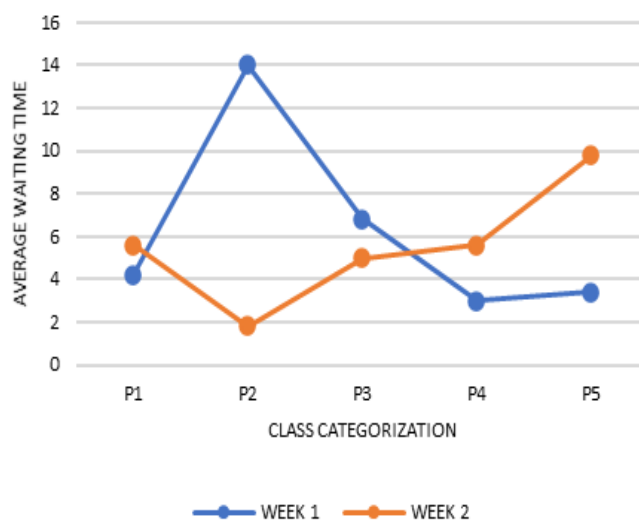| Weeks/Classes	P1	P2	P3	P4	P5
Week 1	7.0	5.2	3.0	8.6	1.8
Week 2	5.2	3.6	11.4	3.4	2.2

Fig. 3 Average arrival and waiting times for public primary school teachers
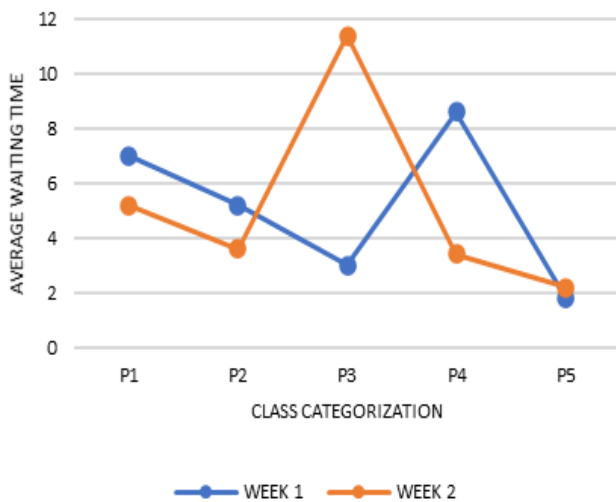
Fig. 4 Average arrival and waiting times for private primary school teachers

Tables 2-5 showed that the average waiting time of pupils for the first arrival is higher than that of the first arrival teachers. In Fig. 3, the waiting time of the teachers in the public schools for the first week was longer. In Fig. 4, the waiting time though lower than that of the public schools but revealed a unique pattern.
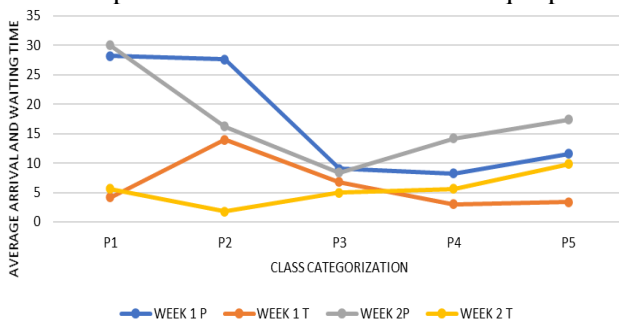

Fig. 5 Comparative analysis of arrival and waiting times of pupils (P) and teachers (T) for public schools
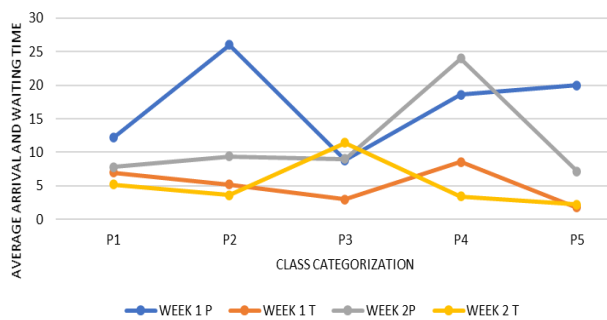

Fig. 6 Comparative analysis of arrival and waiting times of pupils (P) and teachers (T) for private schools

From Fig. 5 and 6, we observed that the arrival and waiting time of pupils was longer compared to that of the teachers. Therefore, this suggests that teachers may have distinct characteristics with time management. Furthermore, this comparison implies that, mostly, the pupils arrive at the class before the teachers' arrival.

3.2. Results Based on ANOVA Procedure

The computation of the F-value is based on the ANOVA procedure in Table 1. The data set was collected, where $K = 5$ days, each with m = 5 classes. This implies that the total collection $N_T = Km = 5(5) = 25$ subjects. Equations (1-2) were applied with the similar computational procedure above to obtain the summarized information in Tables 6-13, respectively. The title of each table revealed the information being analyzed. The degrees of freedom are $df_1 = K$-1, $df_2 = N_T$-K at a 5% significance level, and the F statistic is computed. The table value or F-critical value is 2.87. If the computed F-statistic is greater than the F-critical value, then reject the null hypothesis, indicating that the mean waiting and arrival times for teachers and pupils in each class are not equal.

Table 6 ANOVA for average arrival and waiting time for pupils in public primary schools (Week 1: first arrival)

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F (*p*-value)
Between treatment	2041.84	4	510.45	4.23 (0.012)
Error sum of square	241.6	20	120.8	
Total	4457.84	24		

Table 7 ANOVA for average arrival and waiting time for pupils in public primary schools (Week 2: first arrival)

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F (*p*-value)
Between treatment	1256.56	4	314.14	3.26 (0.033)
Error sum of square	1930	20	96.5	
Total	3186.56	24		

Table 8 ANOVA for average arrival and waiting time for pupils in private primary schools (Week 1: first arrival)

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F (*p*-value)
Between treatment	913.84	4	228.46	3.64 (0.022)
Error sum of square	1254.8	20	62.74	
Total	2168.64	24		

Table 9 ANOVA for average arrival and waiting time for pupils in private primary schools (Week 2: first arrival)

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F (*p*-value)
Between treatment	995.44	4	248.86	3.34 (0.030)
Error sum of square	1488.8	20	74.44	
Total	2484.24	24		

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Table 10 ANOVA for average arrival and waiting time for teachers in public primary schools (Week 1: first arrival)

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F (p-value)
Between treatment	416.24	4	104.06	3.35 (0.030)
Error sum of square	620.8	20	31.04	
Total	1037.04	24		

Table 11 ANOVA for average arrival and waiting time for teachers in public primary schools (Week 2: first arrival)

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F (p-value)
Between treatment	162.16	4	40.54	4.22 (0.012)
Error sum of square	192	20	9.6	
Total	354.16	24		

Table 12 ANOVA for average arrival and waiting time for teachers in private primary schools (Week 1: first arrival)

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F (p-value)
Between treatment	155.84	4	38.96	2.94 (0.046)
Error sum of square	264.8	20	13.24	
Total	420.64	24		

Table 13 ANOVA for average arrival and waiting time for teachers in private primary schools (Week 2: first arrival)

Source of variation	Sum of square (SS)	Degrees of freedom (df)	Mean squares (MS)	F (p-value)
Between treatment	266.16	4	66.54	3.10 (0.039)
Error sum of square	429.2	20	21.46	
Total	695.36	24		

Based on the F-statistic and the F-critical value, the F-statistic is greater than the F-critical value. Hence we reject the null hypothesis, implying that the average arrival and waiting for both teachers and pupils in each class are different. When comparing the respective *p*-values with a 0.05 level of significance, the *p*-value approach corresponds to the critical value decision. We conclude that the test is statistically significant at a 5% significance level.

3.3. Discussion

The study revealed that the pupil's average waiting time is much longer than the average waiting time of teachers in both public and private schools. However, the pupils in private schools have a longer average waiting time than the pupils in public schools. The null hypothesis was rejected, which implies that teachers' and pupils' average waiting time is not equal.

Further investigation was initiated, and the reasons adduced were the distance from home to school and traffic gridlock when both teachers and parents are taking their ward to school. This study showed that the teachers are usually in their duty post mostly at 8:00 a.m., which is comparable with the school start time [24]. Some existing literature focused on the late coming of teachers and students in the junior secondary school and others. The results presented in this study are based on an urban study.

The research report on school start time correlates with the finding reported in this discussion that teachers arrived at their duties post at most 8:00 a.m., implying school start time [25-28]. In general, the notion that public-school teachers are often not on duty posts on time is readily not valid based on this study. The mean technique adopted in this discussion is unique in its computational framework [29]. However, teachers residing outside the school premises must contend with fluctuating early arrival to duty posts. This study observed that if staff quarters are within the premises of the schools, teachers will resume early to their duty posts. The study also identifies school distances from residential areas and the numbers of available schools within manageable distances as partly responsible for late arrival and long waiting time of pupils, parents, and teachers alike. The study based on the analysis of variance revealed that the null hypothesis is rejected at a 5% level of significance, implying that the arrival and waiting times of pupils, parents, and teachers are not equal. The analysis also revealed that the average waiting time is approximately 17 minutes; the implication is that the teachers arrived at their duty posts mostly at 8:00 a.m.

3.4. Significant Statement

This study revealed that most career parents are affected by the late arrival of some teachers in their children's schools. This implies that the late arrival of some teachers has reciprocal effects on parents who do not want to leave their children unattended. This new procedure will assist school administrators in determining the arrival and waiting times of pupils and teachers. If implemented, the findings based on the average waiting time of pupils and teachers will improve class activities.

This study will assist parents, school administrators, and the ministry of basic education in monitoring the activities of public and private primary school teachers. It will improve person-hour services to all-inclusive. It further boosts the morale of parents to send their children to either public or private schools. It will reduce the waiting time of parents and propel them to

ready their children for school on time. It will help parents to resume their duty posts early.

4. Conclusion

The average waiting time analysis showed that the pupil's arrival average waiting time is longer than the teacher's arrival average waiting time. The analysis showed that both categories of teachers in the Delta State capital, Asaba, have approximately equal waiting times. This study showed that some pupils arrived in their classes earlier than their teachers, and the contrary is true. Though the finding did not indicate that the teachers arrive after 8:00 a.m., some are not in their duty posts before 7:30 a.m. The study revealed that most teachers are in their duty post at must 8:00 a.m. Therefore, this study revealed that waiting time problems are associated with public and private schools in the study area. For solving the waiting time problems in the schools mentioned above, especially for teachers, a clock in the device should be introduced to monitor the arrival time of teachers to enhance parents' and guardians' confidence in sending their children to school. In this regard, the parent-teacher association should be enhanced to solve the problems of pupils that come late to school after the regulated time. Therefore, we also suggest that a monitoring unit from the ministry of education should be activated to solve the waiting time problem. This study has affirmed that waiting time problems exist for both public and private schools in the study area.

5. Limitation

The main limitation of this study is the number of participating schools used in this study and the location of the schools. The output of this study may vary based on different geographical regions in Nigeria. Future studies could extend this research to different locations and regions in Nigeria to investigate the effect of waiting time problems in public and private primary and secondary schools.

Acknowledgment

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