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A proposed Decision Support System for Managing Educational Human Resources Based on GIS

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Abstract
No one denies that the modern city is overflowing with large increasing rates, especially during school days. The average of rush hours obviously increases in the morning (school starting time) and in the afternoon (school ending time). Management of education services represents one of the major challenges especially in the developed countries. The application of GIS in this field provides a great help in facilitating and organizing these services. The main objective of the work is to evaluate primary schools in the western neighborhood of Mansoura city according to their spatial distribution, relationships between the number of students, teachers and classrooms. Accordingly, the spatial and descriptive data about primary schools in the studied area were collected, stored, managed and analyzed under the GIS environment. Spatial distribution of the studied features and nearest neighbor analysis, were carried out in this work. The achieved results indicate that primarily schools are clustered within the studied area. The number of students was highly correlated with the number of teachers and the number of classrooms (r= 0.80 and 0.88, respectively). Most of the studied schools were over loaded with students, where there was deficiency in the number of classrooms. Accordingly, more classrooms (about 280 classrooms) need to be added to the currently overloaded schools; however most of these schools are limited in their surface area. In this case, new schools (about 18 schools) need to be established to cover this situation, especially in places where there is an increase in the number of students and a shortage in primary schools.

Keywords
Gis, Educational Services, Primary Schools, Cluster Analysis.

I. Introduction

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and represent several types of referenced geographical data. In other words, it is an organized collection of computer hardware, software and personnel to efficiently capture, store, update, manipulate, analyses and display all forms of geographically referenced information. It is used in solving complex research, planning and management problems [7-15]. GIS software packages include utilities and tools, which are utilized for building and determining the locations of geographical features. ArcGIS software developed by the Environmental Systems Research Institute (ESRI) is used in spatial data representation. It includes several functions and tools which covers a wide variety of applications. In general, the spatial distribution of schools is not compatible with the standards of urban planning and management. Some modern cities have insufficient educational services and there is difficulty for both students and teachers to access these areas. Most cities are becoming very crowded, especially during school days. Rush hours obviously increase in the morning (school starting time) and in the afternoon (school ending time).

Spatial distribution of educational services can be carried out through a wide variety of analyses; one of them is the average nearest neighbor distance. It calculates a nearest neighbor index based on the average distance from each feature to its nearest neighboring feature. It shows either the schools are randomly distributed within studied area or clustered in certain locations. Modeling in GIS is another tool that can help in programming or developing statistical models to deal with spatial data layers [3]. A decision support system (DSS) is a model-based or a knowledge-based system intended to support decision makers in semi-structured or unstructured situations. A DSS is not meant to replace a decision maker, but to extend the decision making capabilities. It uses data, provides a clear user interface, and incorporates the decision maker's own insights. Decision support systems are interactive, computer-based systems that aid users in the judgment and selection of activities. They provide data storage and retrieval that enhance the traditional information access and retrieval functions with support for model building and model-based reasoning. They support framing, modeling, and problem solving [1].

II. Related work

GIS has been widely used worldwide nowadays in educational services. For example, in [4] the authors analyzed the spatial distribution of primary schools. Their objectives were to make an inventory of the schools in their area. They create a geo-database of the schools and to analyze the pattern of the school distribution in their study. In [2] the authors utilized the GIS for educational facilities, where each educational unit has easy access to the common database. This database was created based on administration management system in Georgia and this database is dynamic and it can be developed [2]. In [5] the authors have developed a GIS-based decision support system (DSS) to establish geo-referenced data and information of Higher Education Institutions (HEIs) and programs. This is to incorporate and build upon current understanding of the spatial distribution and cartographic modeling. This is in addition to operationalizing such DSS for policy research development in HEIs [5]. The paper attempts to show how GIS could be used in the planning processes and decisions of educational services.

III. Materials and Methods

The objective of the work was to evaluate primary schools in the western neighborhood of Mansoura city according to their spatial distribution, relationships between the number of students, teachers and classrooms. This is in addition to providing decision makers with the more accurate information required for improving educational services in the studied area.

A. Description of study area

In this work, the study area is located between these coordinates (31°20' 54.83" to 31°24' 13.43" E and 31° 0' 45.06" to 31°2'54.68" N) as illustrated in Figure 1. It covers an area of about 11.67 km^2. There were 33 primary schools in that area. The coordinates of these schools were recorded using a GPS device. Data of these schools were also obtained from the educational management of the western neighborhood. All the obtained data either spatial or descriptive data were integrated under the GIS environment.

B. Data layers

Thematic layers for locations of primary schools, street networks, residential areas, and proposed student locations were created under the GIS environment. Data layers consist of a set of logically related geographic features and their attributes.

C. Neighborhood analysis

The nearest neighbor analysis is considered as the most significant engineering and statistical technique used in studying the nature of the patterns of spatial distribution of a geographical phenomenon. It provides a statistically precise measure that is based on the mathematical foundations in measuring the dispersion of phenomena about each other and determines the modality of spread of spatial distributions. It measures the geographical location of each point and geographical location of the nearest point to it, and then it determines the average distance between all these points. After that it divides the estimated average by expected average for the entire distance between these points. The following equation used to extract the Nearest Neighbor index**:**

$$R = 2M\sqrt{N / A} \quad (1)$$

Where: R is the nearest neighbor distance or ratio, M is the arithmetic average between each point and the nearest neighboring point, N is the number of points in the research area and A is the research area. Depending on the value of R which ranges between 0 and 2.15, three main patterns of spatial distribution can be identified as illustrated in Figure 2. These patterns are clustered (R= 0 to 0.99), random (R= 1), and dispersed (R= 1.1 to > 2).

The Z-Score is also used to find out if the distribution pattern takes a normal distribution or not. It is calculated at a significance or confidence level of 0.05 either negatively or positively at both ends of the bell distribution. The Z-Score is calculated using the following equation:

$$Z = (X_i - \overline{X}) / S \quad (2)$$

Where: Z is standard values for point X_i, $\overline{X}$ is the arithmetic average, and S is the standard deviation.

D. Statistical analysis

The linear interrelationships between the number of students and the number of classrooms and teachers were carried out according to Steel et al. (1997) [6].

E. Flow Chart of Data Analysis and Manipulation

The procedures used in data analysis and manipulation are illustrated in Figure 3. It shows how both spatial and descriptive data were integrated in a geodatabase under the GIS environment. It also demonstrates the different types of spatial analysis that were carried out on the school data.

IV. Results and Disscutions

1. Nearest Neighbour Analysis of Primary Schools

The nearest neighbor analysis was carried out using the spatial statistics under Arctoolbox in ArcGIS Desktop 10.3. The result shows that the distribution of primary schools in the area The obtained results revealed that primary schools were clustered within the studed area as illustrated in Figure 4. The nearst neighbor ratio was 0.57 and the z score was -4.68 at a significance level 0.01. This indicates that there is less than 1% likelihood that this clustered pattern could be the result of random chance.

2. Primary schools and data analysis

Table 1 shows the geo-database for some of the studied primary schools. It includes school names, number of classrooms, number of student and number of teachers within each school in 2014. Figure 5 shows the spatial distribution of primary schools based on the number of students in each school. On the other hand, Figure 6 demonstrates the difference between the current and the ideal number of students in the studied schools. It can be observed that some schools suffer from an increase in the number of students. This puts a higher potential on the educational services and thus influence their functionality, performance and efficiency. The total number of students was 22834 and the number of the current classroom was 519 means that the average number of student in each classroom is equal to 44 pupils in each classroom higher than the ideal number of 30 pupils. The increase in the number of students above the ideal number was about 7264 student, which represented 3.14% of the total number of students. This increase in the number of students varied from one school to another. Higher numbers were found in 24 of the studied schools as represented in Table 1. School numbers 5, 6, 8, and 10 had the highest increase rates, which were 1089, 827, 1020, and 1053 student, respectively. On the other hand, there were shortage in the number of students in school numbers 13, 14, 15, 16, 18, 20, 28, 29, and 33 and shortage was about 43, 239, 85, 402, 55, 80, 90, 80, and 126 students, respectively.

The ideal number of students was calculated based on a classroom capacity of 30 students. The ideal number of students was subtracted from the current number to find the overload. Figure 7 shows the spatial distribution of the difference between the actual and the ideal number of student in over the studied schools. The overload was divided by 30 to find out the needed number of classrooms. It was found that about 280 classrooms are needed to handle that increasing number of students within the study area. Figure 7 illustrates the spatial distribution of the actual number of classrooms in the studied schools, whereas, Figure 8 illustrates the distribution of primary schools based on the shortage in the number of classrooms. It shows the number of classrooms that should be added to each school in order to minimize the number of student in each classroom to about 30 students. It was noticed that the majority of schools in the studied area suffer from a shortage in the number of classrooms. That shortage was very obvious in school numbers 5, 6, 8, and10. In the contrary, there was a surplus in number of classrooms in school numbers 36, 29, 34, and 35. This indicates that additional classrooms need to be added to the current overloaded schools; however most of these schools can't handle more classrooms either because they are old or due to their limited school space. In this case, new schools need to be established to cover this situation, especially in places where there is an increase in the number of students and

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shortage in the number of classrooms. Also, a number of students can be redistributed on the existing schools that have plenty of classrooms. Based on the average number of classrooms in the existing schools, which was 16 classrooms in each school, about 18 new schools need to be founded. Figure 9 shows the spatial distribution of teachers in the studied schools. It reveals that the number of teachers was associated with the number of students and the number of classrooms in the studied schools. By dividing the total number of students by the total number of teachers we get the teaching capacity for each teacher. This teaching capacity was about 20 students for each teacher.

3. Correlation between the number of classroom and students

The number of students was tested against the number of classrooms using the liner regression model. A highly positive significant correlation was found between the number of students and the number of classrooms available in the studied schools (r=0.88, p=0.001) as represented in Figure 10. This indicates that as the number of students' increase as the number of teachers increase and vice versa.

4. Correlation between the number of Teacher and students

The number of student was tested for against the number of teachers using the liner regression model. A highly positive and significant correlation was found between the number of student and the number of teacher in the studied schools (r=0.80, p=0.001) as illustrated in Figure 11. This indicates that as the number of students increase the number of teachers increase and vice versa.

V. Conclusion

The application of GIS could be very helpful in the management of educational services. It can provide decision makers with more accurate information, which could provide a great help in facilitating and organizing these services within a short time and with less effort and money. Primarily schools were clustered in certain locations within the studied area, which resulted in an imbalance in the spatial distribution of these schools. In other words, primary schools were concentrated in certain areas and lack in some others. Also, there were higher correlations between the number of students and the number of teachers and classrooms, most of the studied schools were over loaded with students. Consequently, more classrooms (about 280 classrooms) need to be added to the overloaded schools. However, most of the existing schools are limited in their areas; therefore new schools need to be founded to cover this problem. These new schools (about 18 schools) should be built in these areas that are suffering from shortage in primary schools and have higher number of students. Also, students should be equally distributed among the existing schools, where some schools have plenty of classrooms.

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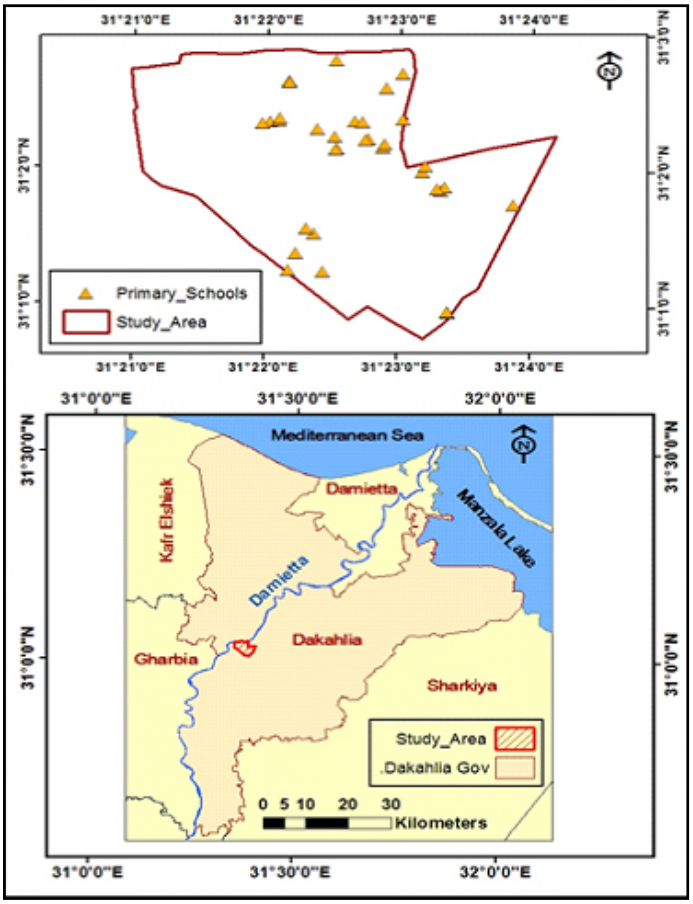

Fig.1 : Locations of primary schools in the studied area.

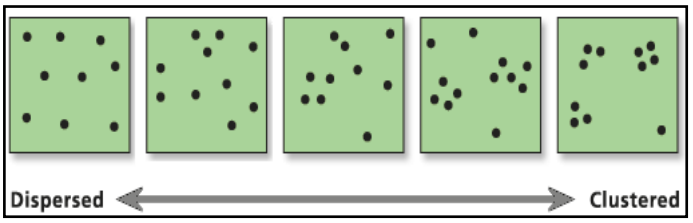

Fig. 2. Identification of the main patterns of spatial distribution.

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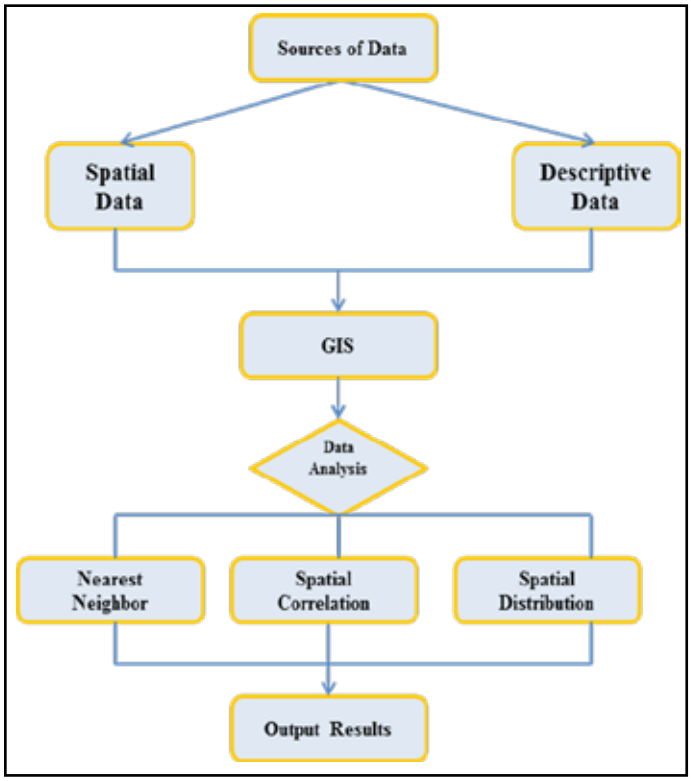

Fig. 3 : Flowchart of data analysis used in this work.

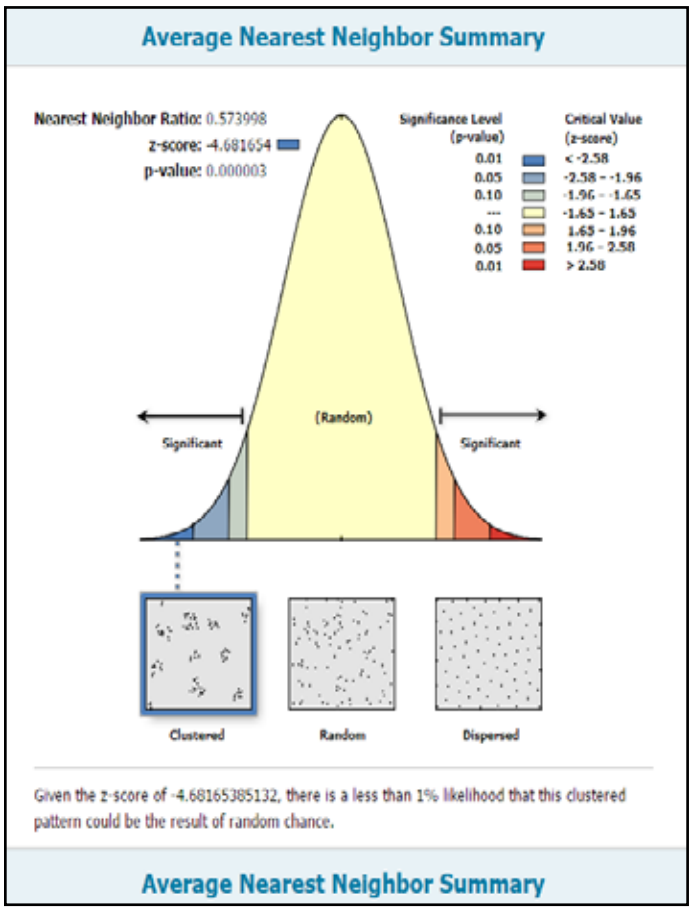

Fig. 4 : Nearest Neighbor Analysis of the studied Primary Schools in Mansoura city.

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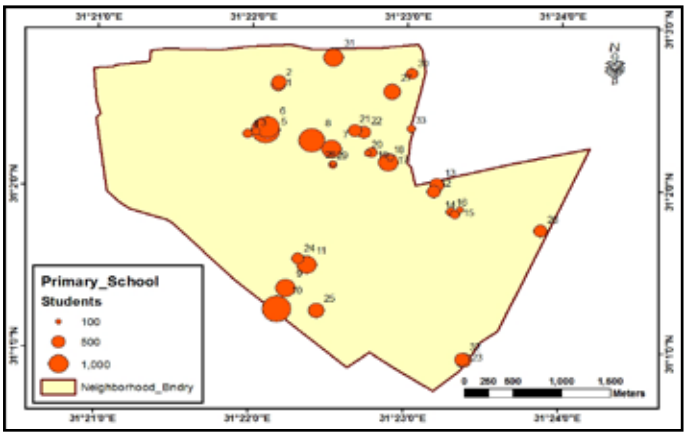

Fig. 5 : Spatial distribution of the actual students in the studied schools.

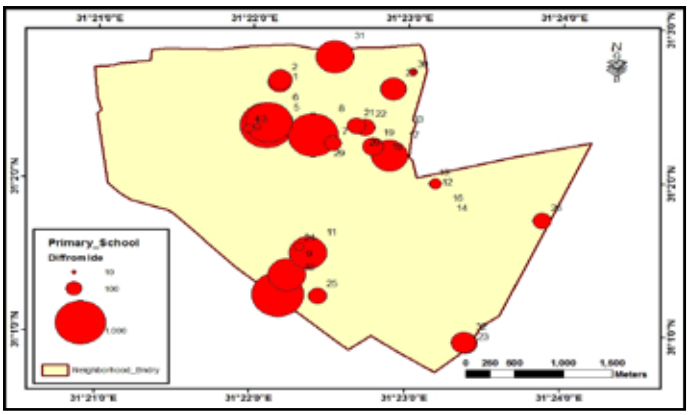

Fig. 6 : Difference between the current and the ideal number of students in the studied schools.

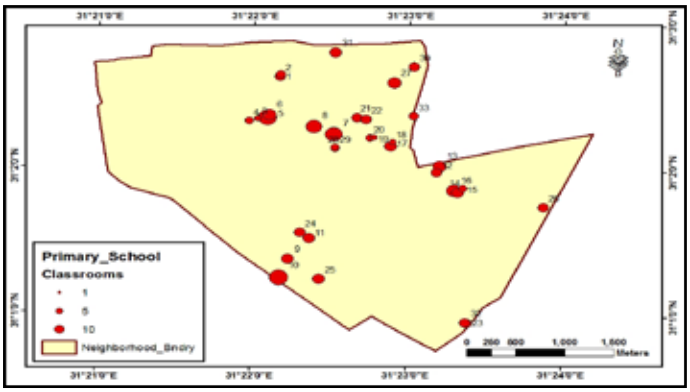

Fig. 7 :Spatial distribution of classrooms in the studied schools.

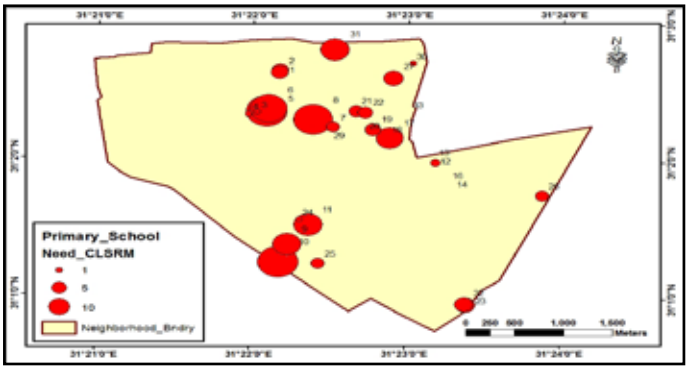

Fig. 8 : Needed number of additional classrooms in the studied schools.

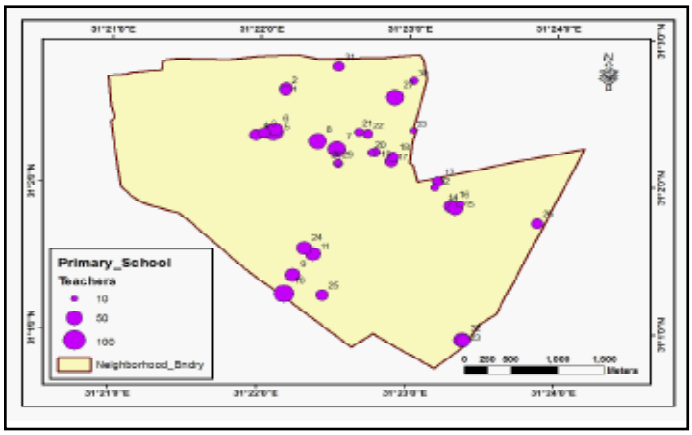

Fig. 9 : Spatial distribution of teachers in the studied schools.

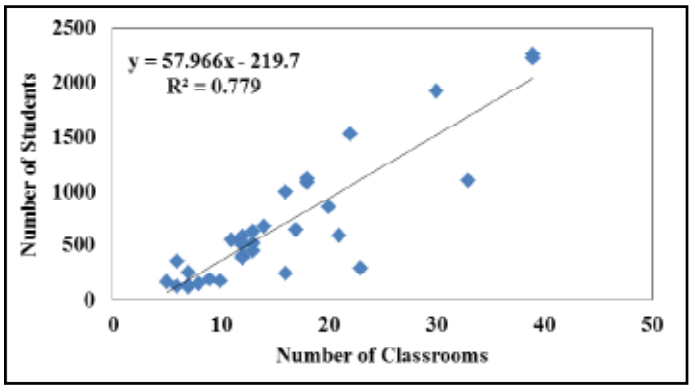

Fig.10 : The linear relationship between the number of students and the number of classrooms.

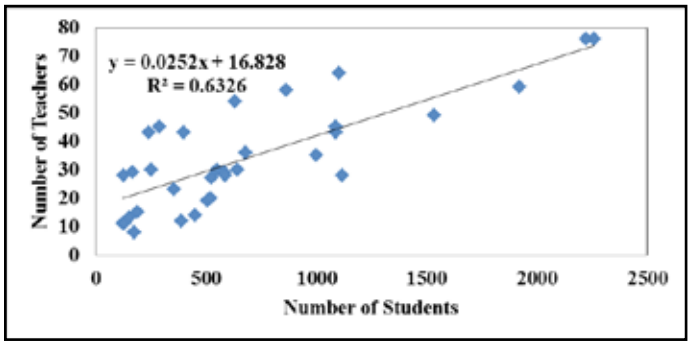

Fig.11 : The linear relationship between the number of students and the number of teachers.

Table 1 : Database for some of the Primary Schools in the studied area of Mansoura City.

No	School Name	No of Classrooms	No of Students	No of Teachers	Ideal No of Students	Diff. between Current and Ideal	Needed No of Classrooms
1	ahmoud Taha school	11	548	30	330	218	7
2	Sidi Yassin School	12	581	29	360	221	7
3	Imam Mohammed Abdu Experimental School	5	168	29	150	18	1
4	Khalid bin Walid School	7	250	30	210	40	1
5	Imam Mohamed Metwally Al-sharoay School	39	2259	76	1170	1089	36
6	School of El Shaheed Khaled Mohammed Toukhy	22	1532	49	660	872	29
7	School Abu Bakr Al-Siddiq	33	1104	64	990	114	4
8	School Omar bin Abdul Aziz trial	30	1920	59	900	1020	34
9	Al-Firdaus Primary School Benin	18	1087	43	540	547	18
10	Imam Mohamed Metwally El Shaarawy School	39	2223	76	1170	1053	35
11	Paradise Elementary School Girls	18	1087	45	540	547	18
12	Imam Shafi'i Institute	13	450	14	390	60	2
	Total	519	22834	1131	15570	7264	280