

THE USE OF ASSIGNMENT PROBLEM MODELS TO ASSIGN TEACHERS TO CLASSES: A CASE STUDY OF ADO BOBI PRIMARY SCHOOL, MARIGA, NIGER STATE, NIGERIA

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Abstract

One of the most powerful and special tool of operations research that has the capacity to help head teacher, principal, head of department or course coordinator to determine the optimal assignment that will maximize teacher's or lecturer's effectiveness and minimize class preparation time is the assignment model. Assignment problem is used, for instance, in education, medicine, rail transport, production planning, and telecommunication. In this research, assignment problem model is used to find how the school administrators should assign her teachers (i.e Hauwa Hussaini, Raliya Mohammed, Muhammad Ibrahim, Serah Zakariya, Ibrahim Salisu and Jamilu Abbas) to the classes in school (Primary 1 to 6). The Hungarian method of assignment problem was used by a statistical package (Excel QM). In order to minimize number of failure, the result shows that; Jamilu Abbas should be assign to Primary 1 with the least number of failure 17; Primary 2 with only 21 failure to be assigned to Hauwa Hussaini; While, Ibrahim Salisu should handle Primary 3 with 38 failure; Raliya Muhammad assigned to Primary 4 which has failure of 33; Primary 5 with 27 fails assigned to Serah Zakariya and Muhammad Ibrahim for Primary 6 with record of 26 failure. These assignment will give a minimum of 161 failed pupils in the school with 2,662 pupils.

Keywords: Assignment, Hungarian Method, Education, Teacher, Pupil, Minimize

1.0 Introduction

In every developed and developing nation of the world, education remains the main process through which effective knowledge, discipline, professions, skills and values are acquired by the citizens. It plays a critical role in human capital development which is a key to scientific, technological and societal advancement. Education is considered as a sustainable way leading to economic growth and development due to the fact that, it reduces level of unemployment in the economy, increases productivity of the country's work force, provides better economic opportunities, improves the standard of living, increase efficiency of labour and produces skilled manpower capable of strengthening and boosting our economic [1].

However, education is the most crucial tool to improve human capabilities and to achieve the desired goals of socio and economic development. Education allows individuals to make informed choices, broaden their horizons and opportunities and to have a voice in public decision-making. At the macro level, education means strong and sustainable economic growth due to productive and skilled labour force. At the micro level however, education refers to as higher income generating opportunities because it increases the chances of being employed.

National development starts from the individual; that is, national development is a function of individual development in the country. Meanwhile individual development is the level of education individual gets. In Nigeria, the education system is 6-3-3-4, starting from primary school in which individual is expected to spend 6 years getting elementary knowledge after which they move to Junior secondary school to spend 3 years and another 3 years in Senior Secondary school. The final stage is higher institution where an individual is expected to spend a minimum of 4 year or more depending on the demand of the course of study. At this stage, individual in higher institutions is expected to be trained by experts called lecturers in their course of study. These experts impact their students with their knowledge in order to increase their intellectual capacity [2].

Education is the bedrock of nation's economic, political, technology, and scientific development. It is expected to increase individual knowledge, improve social and economic life which translates to national development. It is a powerful weapon that can be deployed to fight poverty, increase the standard of living and bring everyone in the country from darkness to light.

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In their research, they opined that the level of teacher's effectiveness affects the quality of education students get at any level of education, i.e. be it primary, secondary or tertiary level [3]. On the other hand, it was argue that the impact of teachers or lecturers on students is indisputable in the society. It is the responsibility of the head master, principal, head of department or course coordinator to assign courses to teachers or lecturers based on their expertise and their level of effectiveness at the beginning of each academic session or semester [4].

However, one of the powerful and special tool of operations research that has the capacity to help head master, principal, head of departments or course coordinators to determine the optimal assignment that will maximize teacher's or lecturer's effectiveness and minimize class preparation time is the assignment model. Assignment problem is used, for instance, in education, medicine, rail transport, production planning, and telecommunication.

The assignment problem is nothing else than a balanced transportation problem in which all supplies and demands are equal to one. Assignment problem arises in diverse situations, where one needs to determine an optimal way to assign subjects to subjects in the best possible way. Thus, it arises as a result of different decision-making situations relating to job or task assignment in our day-to-day activities. In other word, the assignment technique is applied in the class of very practical linear programming model to assign a number of source variable jobs or persons to equal number of machines or tasks with minimum cost or maximum profit. The job to machine or person to task selection complicacy is generally known as Assignment problems [5] and [6].

The assignment model building algorithm is a powerful tool that is executable through a computer program for assigning n number of teachers to n number of classes, for n larger than 5 and by the way, it can ease the decision-making procedure for solving a real-life problem that has to do with the maximum effective and minimum cost allocation or assignment.

Assignment problem is a technique in operation research that can be used to derive optimization, it has capacity to minimize and maximize depending on the objective of the model. It can be used in allocating jobs to machine, operators to machine, sales-personnel to territories, workers to supervisor, courses to lectures, engineers to construction sites among other with focus to minimize or maximize. Assignment model is a special class of the linear programming which has to do with allocation of jobs to machines, personnel to location. Basically, assignment model has two objectives either to minimize or maximize. In assignment model, all tasks to be performed must be assigned on one-on-one basis, two tasks or jobs cannot be assigned to machine or personnel.

Similarly, assignment problem also known as one-to-one matching problem comes under linear programming, which has to do with allocation of jobs to machines, personnel to location. Basically, assignment model has two objectives either to minimize or maximize. In assignment model, all tasks are to be performed and must be assigned on one-on-one basis; two tasks or jobs cannot be assigned to a machine or a personnel. The assignment problem plays a significant role in solving real life problem and it is acceptable and well utilized tool around the world [7].

Assignment problem is a one case of transportation problem where number of jobs (or origins or sources) and number of facilities (or destination or machines or person and so on) are equal. It arises as a result of different decision-making situation relating to job or task assignment in the day-to-day activities [8].

However, assignment problem is also called maximum-weight matching and is treated as a special case of the transportation problem. The researchers perceived Assignment Problem (AP) as a discrete and combinatorial problem where agents are assigned to perform tasks for efficiency maximization or cost (time) minimization. Thus, the goal of AP is to assign agents (usually workers) to perform tasks (usually jobs) and to maximize total efficiency or minimize entire cost/time [9].

According to [10], the major objective of assignment problem is minimization of cost, time, space and maximization of profit, effectiveness, efficiency and others. It can be used in allocating jobs to machine, operators to machine, sales-personnel to territories, workers to supervisor, courses to lectures, engineers to construction sites among other with focus to minimize or maximize. Assignment model is a class of linear programming that is similar to the transportation problem; it assumes that a job can only be assigned to one man or one machine in order to determine optimality.

In a study carried out by [11] believed that assignment problem is one of the combinatorial optimization problems in mathematics that is fundamental. They also viewed the assignment model as a technique that answer the question how we can assign n number of objects to m number of objects in the best possible way. Also, believe in assignment problem is a management science tool that can be deployed to achieve optimization in both manufacturing and service system [12].

1.1 Classification of Assignment Problem within the education Domain

Assignment problem has been classified into Timetabling Problem and Allocation Problem

Timetabling Problem.

Timetabling problem is considered as a type of assignment problem. A timetable usually provides information about the time for particular events to occur and eventually relates to the resources allocation. Besides, timetabling is described as an assignment of events to a limited number of times lots and rooms subject to prescribed constraints [13],

According to [14] "a timetabling problem is a problem with four parameters: a finite set of times; a finite set of resources; a finite set of meetings; and, a finite set of constraints. The problem is to assign time and resources to the meetings so as to satisfy the constraints as much as possible." As such, timetabling problem is classified into three sub problems, which are Examination Timetabling Problem (ETP), Course Timetabling Problem (CTP), and School Timetabling Problem (STP). They are further discussed in the following subsections.

Examination Timetabling Problem.

The Examination Timetabling Problem (ETP) is defined as an assignment of a set of examinations to a set of timeslots while

simultaneously satisfying several problem constraints. According to [15], ETP is defined as a process of assigning examinations to a limited number of timeslots with the aim of producing high quality timetable subject to constraints. In fact, the main objective of this problem is to produce timetable that optimizes certain objective functions. The researcher claimed that ETP is considered as an NP-hard real-world problem, which is rich and diverse, besides involving some significant levels of information from the connected problems.

Course Timetabling Problem.

Course Timetabling Problem (CTP) refers to the process of assigning courses, rooms, students, and lecturers to a fixed time period, typically a working week, while satisfying a given set of constraints. According to [16], University course timetabling is considered as a weekly schedule of all university lecturers to a set of courses and at the same time to prevent the lecturers to have students in common at two different timeslots. Moreover, they stated that, in reality, examination and course timetabling problem are about the same in some attributes but portray some variances. For instance, in examination timetabling, the room may have more than one examination scheduled at the same time, providing that the room seating capacity is not exceeded, while this is impossible for course timetabling, where the assignment normally allows one course per room, per timeslot.

School Timetabling Problem.

The School Timetabling Problem (STP) is about generating school timetable that usually follows a cycle every week for all classes, in which the objective is to avoid teachers from attending two classes at the same time. In school timetabling, students are normally pre-assigned, while only teachers and rooms need to be assigned in the timetabling problem. However, STP is aimed at assigning period for teacher to certain subject in a specified group by considering groups of students and teachers in a fixed period scheduling [17]. According to [18] STP is considered as NP-complete or NP-hard problem that depends on the intricacy of the problem in relation to various constraints.

Allocation Problem.

Allocation problem has been considered as a type of assignment problem. In fact, the allocation problem has been cited widely as a fundamental combinatorial optimization problem under optimization or operation research branch. The allocation problem is a famous problem discussed in the literature with various types of applications, especially within the education domain. This problem is categorized into three sub problems, which are; Student-Project Allocation Problem, New Student Allocation Problem AND Space Allocation Problem.

Student-Project Allocation Problem.

The student project allocation problem (SPAP) is related to assigning a person to a particular project or cases based on preference or interest of student and lecturer. SPAP includes a set of projects, students, and lecturers, whereby every unique lecturer is offered a project and both the lecturers and projects have some capacity constraints.

New Student Allocation Problem.

The new student allocation problem (NSAP) is a clustering problem in allocating new students to their corresponding class with minimum intelligence gap by sorting method: a group of new students with similar ranking and assigned into the same class.

Space Allocation Problem.

The space allocation problem (SAP) refers to a problem to allocate resources to space areas, for example, allocating rooms and at the same time satisfying several requirements and constraints [19]. They conducted a study on course and lecture assignment problem solver for educational Institution in Odisha state of India. The assignment problem was formulated and solved with Hungarian method based on the data obtained from five lecturers in a department in the specific department in the specific institution. The result of the study revealed that the department will experience 465 maximum effectiveness on the five topics.

A study conducted by [20] applied assignment model to Alhram Plaza Centre in Saudi Arabia who specializes in the sales of clothes. Optimality was discovered in the allocation of workers to a different section in the store. They also used linear programming to solve under allocation and over allocation of classroom in Premier Nurse's Training College, Kumasi. Optimal solution was determined when solved with the help of POM-QM for Windows

In a research of [21], a mathematical model was developed solve course – classroom assignment problem in Faculty of Engineering and Industrial Technology at Silpakorn University in the First Semester, 2012. Excel's Premium Solver was employed to solve the model in order to reduce classroom cost. Optimal solution was determined and total cost of classroom was reduced.

The assignment problem used to solve staff-subject allocation with the aim of maximizing quality of knowledge teachers' impact to students' lives. Optimal solution was obtained at the end of the analysis [22].

This researcher employed assignment model in solving teachers' allocation problem in order to minimum time to be spent in preparing for lecturers. Four teachers who are capable of taking four different courses were selected for the study. Optimum solution was discovered with the help of the Hungarian method employed to solve the assignment problem [23].

This study developed two mixed integer programming models. They solved the model with non-linear constraints and a quadratic objective function using a Tabu search algorithm and they used CPLEX to solve the other linear model. By comparing the two solution methods they confirmed the effectiveness of the Tabu search approach. They aim to balance the nurses' workload within different categories [24].

The research carried out by [25] coupled the assignment and routing problems in the Home Health Care (HHC) structures. They focused on the interaction between assignment and routing, where the output of the assignment problem is incorporated as an input into the routing problem, with the assumption of one district.

This study shows the developed structural policy to assign a newly admitted patient while balancing the operators' workload by minimizing the cost function that penalizes the operators' overtime [26]. They consider that the patients' demands are either deterministic or stochastic.

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In their research conducted, they present a combination of linear programming, constraints programming and (meta) heuristics for a HHC problem that consider the staff rostering and vehicle routing components while minimizing transportation costs and maximizing satisfaction of the patients and nurses [27].

2.0 Material and Methods

This research focuses on the methods and data collection from the study center, that is, Ado Bobi Primary School Mariga, Niger State.

The problem is formulated in canonical form [28]

$$Z = \sum_{j=1}^n \sum_{i=1}^m C_{ij}X_{ij}$$

$$st = \sum_{i=1}^m X_{ij} = 1, j = 1, \dots, n$$

$$\sum_{j=1}^n X_{ij} = 1, i = 1, \dots, m$$

$$X_{ij} = 1 \text{ or } 0$$

Assignment model is a branch of linear programming that requires n persons to perform m tasks/course

Where;

n = Number of persons to take (teach) the task/course

m = Number of tasks/course to perform (teach)

C = Teacher's effectiveness

i= Row (number representing class)

j = Column (number representing teachers)

X = 1 if class is assigned to a teacher, and 0 if not assigned

Cij = Teacher i effectiveness taking class j

Xij = 1 if teacher i will be taking class j, and 0 if teacher i will not be taking class j

Z = Objective Function (Maximize)

$$Z = C_{11}X_{11} + C_{12}X_{12}$$

2.1 The steps involved for computational procedure to obtain optimal solution

Step One: Create a cost matrix. If the cost matrix is not a square matrix, formulate the problem in a square matrix form by introducing dummy row or column (if the job m is not equal to machine n) to make it balance and form square matrix, the cost of dummy row/column is zero (0).

Step Two: Convert the problem to minimization problem in case the problem objective is maximization, by subtracting the maximum entry in the matrix from all the entries in the matrix. In case of minimization problem, move to step three

Step Three: Perform row reduction by subtracting the smallest entry in each row from all the entries in that same row. So, there will be at least one zero in each row of this new matrix which is referred to as the first reduced cost matrix.

Step Four: Perform column reduction by subtracting the smallest entry in each column from all the entries of the respective columns. So, there would be at least one zero in each row and column of the second reduced cost matrix, as a result.

Step Five: Procedure for determining an optimal assignment.

- i. Starting with first row of the reduced matrix, examine all the rows of this matrix which contains only one zero in it. Mark this zero within the circle and cross out the columns containing these assigned zeros. This process will be going on until all the rows have been examined. If any row deals with more than one zero, then that row will not be considered and it will pass on to the next row.
- ii. Start from the first column and examine all the uncovered columns to find the columns containing exactly one remaining zero. Mark this zero within the circle as an assignment will be made there. Cross out the rows containing this assigned zero. Steps (i) and (ii) will be repeated until all zeros are either crossed out or assigned.

Step Six: If the minimum number of lines required to cover all zeros is equal to the order of the cost matrix, then assignment made in Step 5 is the optimal solution. Otherwise go to next step.

Step Seven: Revised the cost matrix as follows.

Select the smallest element among the uncrossed elements. Then subtract this element from all the uncrossed elements and add the same at the point of intersection of two crossed out lines whereas the other elements crossed by the lines remain unchanged.

Step eight: Go to step 5 and the procedure will be repeated till an optimum solution is obtained.

3.0 Results and Discussions

3.1 The data for this research work are presented in the tables below;

Table 1.1: Shows the number of pupils that fails in each class handled by different teachers

| | Hauwa | Raliya | Muhammed | Serah | Ibrahim | Jamilu |
|---------|-------|--------|----------|-------|---------|--------|
| Class 1 | 70 | 33 | 32 | 36 | 132 | 17 |
| Class 2 | 21 | 128 | 27 | 42 | 80 | 79 |
| Class 3 | 59 | 56 | 89 | 64 | 38 | 98 |
| Class 4 | 45 | 33 | 108 | 47 | 124 | 33 |
| Class 5 | 43 | 90 | 62 | 27 | 61 | 106 |
| Class 6 | 37 | 56 | 25 | 49 | 47 | 19 |

Table 1.2: Number of pupils that fail in each class

| Number of pupils that fails | | | | | | |
|-----------------------------|-------|--------|----------|-------|---------|--------|
| Assignment | | | | | | |
| Data | | | | | | |
| CLASS | Hauwa | Raliya | Muhammad | Serah | Ibrahim | Jamilu |
| Class 1 | 70 | 33 | 32 | 36 | 132 | 17 |
| Class 2 | 21 | 128 | 27 | 42 | 80 | 79 |
| Class 3 | 59 | 56 | 89 | 64 | 38 | 98 |
| Class 4 | 45 | 33 | 108 | 47 | 124 | 33 |
| Class 5 | 43 | 90 | 62 | 27 | 61 | 106 |
| Class 6 | 37 | 56 | 25 | 49 | 47 | 19 |

Table 1.3: Assignments of teachers to classes

| Assignments | Hauwa | Raliya | Muhammad | Serah | Ibrahim | Jamilu | Row Total |
|--------------|-------|--------|----------|-------|---------|--------|-----------|
| Class 1 | | | | | | 1 | 17 |
| Class 2 | 1 | | | | | | 21 |
| Class 3 | | | | | 1 | | 38 |
| Class 4 | | 1 | | | | | 33 |
| Class 5 | | | | 1 | | | 27 |
| Class 6 | | | 1 | | | | 25 |
| Column Total | 21 | 33 | 25 | 27 | 38 | 17 | 161 |

| | |
|--|------------|
| Total Number of Pupils that fails | 161 |
|--|------------|

Table 1.3: indicate the assignment as follows; Jamilu should be assign to teach Primary 1, Hauwa assigned to handle primary 2. While, primary 3 be taught by Ibrahim, Raliya should be allotted to Primary 4, Serah assigned to Primary 5 and Muhammad to take care of Primary 6 in order to have minimum number of failed pupils in the school.

4.0 Conclusion and Recommendations

This paper focuses on the approach to solve the teacher’s assignment problem. The statistical method used to carry out the analysis to solve this problem is Hungarian method. Indeed, the assignment model building algorithm is a powerful tool that is executable through a computer program for assigning n number of teachers to m number of classes. The analysis make it easy for decision-making procedure for solving a real life problem that has to do with the maximum effective and minimum cost allocation or assignment. The computer software (Excel QM) is used for solving the assignment problem having large number of pupils in the school. Our manually computed assignment model by using the Hungarian method give same result that is obtained from using QM software based for computing the same assignment problem. The researchers recommended that the teachers be allotted to a class with high rate of success and least in percentage failure. Also recommended for the use of other statistical software for the analysis.

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