

# Application of Operation Research in Education Sector

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**Abstract:** Education holds the potential to command the course of world events, decipher the biggest mysteries of the universe, and unravel the very fundamental beliefs mankind holds most dear. Education enlightens, empowers, and enables young minds across the globe. But it has some large-scale backend operations which go unnoticed. In the given report, we elaborated the impact of Operation Research in education sector. All in all, by making the most of the heuristic method and developing an algorithmic solution, addressing the various constraints and challenges one can come out with feasible solutions and approaches to the education sector's biggest setbacks.

**Keywords:** Operation Research, Education, Linear Programming, Goal Programming, Integer Programming, Data Envelopment Analysis, Variable Neighborhood Descent (VND) Method.

## 1. Introduction

Education has and always will be the single most important factor contributing to nation-building. The global education administration is one that had always been an uneven playing field. The education sector has left nations a huge gap to fill when it comes to accessibility, affordability, and democratization. Education is not something that is meant for the rich, nor did something leave for those who reside in the heart of the world's technological and economic hubs - which usually consist of only the Tier 1 and 2 cities. Operations Research (OR) has and can continue to play a pivotal role in shaping the future of education across the globe. For instance, new and powerful strides within linear programming problems, data envelopment analysis, goal programming, optimization, and integer programming. By leveraging the many facets of OR we will be able to contribute to curbing problems related to identifying the right school for individual students, optimizing bus routes, institute timetabling challenges, and modelling school meals as per nutritional resources.

## 2. Literature Review

<sup>2</sup>Right from the conception of Operational Research (OR) as a distinctive discipline, OR techniques have been applied to a wide variety of educational issues. Using a scientific approach

OR solves management problems and facilitates efficient decision making on part of managers. Using a range of mathematically oriented techniques that are either developed within the field in question or from other disciplines OR is a highly applied business tool that increases efficiency and productivity.

<sup>3</sup>With the discipline of education OR can help answer questions related to resource allocation. Additionally, source allocation can incentivize efficiency savings for the efficient operation of institutions and can provide a reliable means to measure them. As local governments need to make decisions regarding resource allocation such as the establishment and location of new institutions, the closure of existing ones, and the day-to-day logistics of transport. Allocating budgets, scheduling lessons and assignment of students to courses are issues for managers within the school and university settings that OR can resolve.

## 3. Applications

### 1) Choosing a school or college

- **Problem:** Effective schooling can set the young on a path for life-long learning from prestigious college education to a successful career. A good school not only facilitates learning, but it promotes growth in fields beyond academia. The school environment can determine a student's motivation behind learning and their approaches to life. Considering all the mentioned factors and the interest of the child and parents, it becomes more than important to find the best school for the child.

<sup>4</sup>Before choosing the ideal school for a student, a few of the many basic factors to take into consideration are:

1. Number of seats
2. Number of research students
3. Student - Staff ratio
4. Library Funding
5. Accommodation
6. Teaching pedagogy
7. Companies visiting for placement

8. Sports facilities
9. Opportunities for Extracurricular activities
10. Location

- *Method:* The problem of choosing the right educational institution can be made easier by an operational research tool called Data Envelopment Analysis (DEA), which is a part of the Linear Programming Problem (LPP)
- *Process:* Data Envelopment Analysis (DEA), which is a part of linear optimization, is a technique used to measure the relative efficiencies of Decision-making units. It is a technique that is used in the application of Linear Programming to measure relative efficiencies. DEA has been applied extensively in fields in which the relative performance of units is to be measured. In this context, DEA can be used to compare schools for accurate selection. Not only does the proposed process involve measuring relative efficiencies of schools, but also takes into consideration different types of students, who have varied interests. Based on their individual interests, the most appropriate school is chosen from a pool for candidate schools.
- *Inference:* DEA is a suitable measure to effectively help with the efficiency measurement of schools and universities as it can process several inputs and outputs integrative. DEA can help different departments strive for strategic goals, creating an atmosphere of healthy competition, resulting in an overall improved standard of quality. This would undeniably lead to the positive promotion of the institution as the quantity and quality of research and educational activities advances to create a better brand of the institution at an international level.

## 2) School bus routing and scheduling

- *Problem:* The school bus routing problem is different from managing a public transportation system in the way that it requires additional care and consideration of factors such as student walking distance and familial circumstances. <sup>5</sup>A multi-objective view of the school bus problem is formulated, and a three-stage simplified solution process is outlined and tested. The considerations and consequences of the real-world application of using goal programming to solve this multi-objective problem are discussed.
- *Method:* Goal programming is an approach to deriving the best possible 'satisfactory' level of goal attainment. It is used for solving optimization problems while balancing a trade-off between multiple conflicting objectives.
- *Process-* <sup>5</sup>The six major goals adopted in this paper are as follows:
  1. Limiting maximum walking distance from a student's home to his/her assigned bus stop to one-third of a mile or more.
  2. Guaranteeing each eligible student transportation to school.

3. Avoiding underuse of equipment; balancing school bus load factors.
4. Avoiding circuitous routes and hazardous zones.
5. Avoiding overcrowding in buses.
6. Minimizing the total transportation cost of providing service.

The problem is solved in the following 6 steps.

- Step 1: Establish Subdistricts
- Step 2: Locate Student Homes on a Map
- Step 3: Strategies Bus Stop Zones
- Step 4: Develop Network Structure
- Step 5: Assign Students to Buses
- Step 6: Analyze the Output and Concretize the Bus Routes

*Inference:* 6Goal Programming is used to balance conflicts between multiple predetermined goals. A limit on student walking distance, which is an important element of service, can be incorporated into the siting of bus stops at practically no cost by using templates. The best route of each bus is obtained through the application of a routing algorithm. A practical strategy for providing a useful, reliable, and efficient solution for school bus routing has thus been proposed. School Bus Routing can be accomplished without an exhaustive operation by computer. In fact, retaining human involvement in establishing goals and giving Individualistic-Oriented results in a multi-objective solution process, should lead to an infinitely more satisfactory result.

## 3) Timetabling problem- Integer programming

- *Problem:* Amongst the issues that many schools and colleges face is designing a system that integrates the schedules of teachers and students along with allotting rooms and time slots appropriately. This generally applies to all educational institutions and is also a pillar for efficient training. The school timetabling problem is considered a widely known optimization problem that considers an outsized number of variables and constraints.
- *Method:* As it is combinatorial in nature, solving large and medium problems to optimality is quite challenging. We analyze a mixed-integer linear programming model, which uses a fix-and-optimize heuristic along with a variable neighborhood descent method<sup>7</sup>. This method basically has three main decompositions namely (i) classroom, (ii) teacher schedule and (iii) day.
- *Process:* Previous researchers have indicated that the timetabling problem can be solved by using three different types of decompositions (class, teacher, and day) while combining a fix-and-optimized heuristic with a Variable Neighborhood Descent (VND) method.

In this study, we looked at experiments to test whether this method is applicable to finding high-quality solutions. To make an optimal timetable, we first define the problem with mathematical modelling and formulate the problem along with the constraints and objective function. These timetabling

requirements are categorized as hard constraints (must be satisfied) and soft constraints (should be satisfied whenever possible). The quality of a solution can be judged by the extent of satisfaction with soft requirements. When more soft requirements are satisfied, the solution is considered better. The timetabling solution requires eliminating idle periods between lessons from a teacher's schedule and that it suits pedagogical demands or personal preferences. Teachers at times give personal constraints like requests for consecutive periods (double lessons). These given constraints define a problem called Class Teacher Timetabling Problem with Compactness Requirements (CTTPCR)<sup>8</sup> Using the heuristic method, we reach the initial feasible solution. Then, using an algorithm that considers all the constraints, we attain the resulting solution. There is a range of additional steps involved, such as data set creation and parameter setting.

- *Inference:* Numerous studies have compared these results with integer programming to find that these methods have better solutions in 7 out of 12 cases, as quoted in the literature. These results thus prove that the proposed technique is reliable to be used to solve timetabling problems in educational institutions for efficient learning and training. This also prompts its use to more such problems, along with optimization problems of combinatorial nature.

#### 4) Allocating children to schools

- *Problem:* Assigning children to schools is an opportunity for if done correctly, it is an advantage to society in the long run. The considerations during the assignment include distance to school, sex, and the abilities of the children in question. The problem can be solved by the Goal Programming technique of Operation research.
- *Case study:* So, according to the studies<sup>9</sup>, after briefly reviewing the previous linear programming and goal-programming studies, the model to be used in this study is presented. This study evaluates the consideration of the difficulty of the journey to school, distance, sex, and ability of the children being assigned. The school zoning problem contains constraints that must be respected along with a number of conflicting objectives.
- *Process:* Previous Researchers have argued that GP, which permits trade-offs between goals, is better than traditional approaches to the school zoning problem. It has been demonstrated how such a GP model incorporating six goals can be formulated and solved. This is done considering various assumptions must be met before a zoning scheme for one age cohort can be devised with validity. The pre-emptive method of GP helped in solving the problem of allocating students separately based on various factors.
- *Inferences:* Institutions that don't have access to OR methods often employ teachers on the tasks of allocation work, given that schools are staffed based on the student-teacher ratio. Optimizing the allocation of children to schools' benefits school management by

allowing them to utilize their resources efficiently without endangering the school curriculum. This model might also be more acceptable to parents and students as it helps them decrease inequality over all the schools and get the benefit of minimizing travel costs. This model might help other education institutes as it simplifies the collection of data and allocates accordingly.

It can thus be said that the pre-emptive method of GP can help in solving problems with multiple goals and different priorities much more efficiently. With every additional improvement more dynamic problem that stretch over national levels could be solved.

#### 5) Modelling school meals

- *Problem:* School meal management is an important aspect for the future of children for two reasons.<sup>10</sup> Firstly, students usually eat between one and three meals every day in school. School meals shape children's regular diet and therefore their health. Secondly, due to quantitative production, food-related greenhouse gas emissions (GHGE) can surmount to large levels. Both these effects influence children's lives in the short term and long term.
- *Method:* Develop a GHGE-reduced, nutritionally adequate, and affordable four-week lunch menu optimized for minimum deviation from the current food supply (the latter to maximize acceptability) using the application of Linear Programming (LLP). Evaluate the effects of a reformed menu on food waste, food consumption, and pupils' satisfaction with school lunches.
- *Process:* Optimization has been efficiently used to model cost-effective and nutrition-rich diets which have proved to use climate friendly means of production. And now in this paper we visit an attempt made to test the feasibility of combining the application of a holistic linear optimization method to the planning of school meals in practice.<sup>11</sup>

Using a pre-post design, the consequences of implementing an optimized lunch menu on daily waste matter, consumption, and satisfaction were assessed. Firstly, the food amounts, prices, nutrient content and GHGE - values of all ingredients used for four-week lunch for a previously served (baseline) menu was listed. Using linear programming, this food list was optimized for minimum deviation and constrained to ensure nutritional adequacy and a reduced climate impact. The baseline and intervention menus were served for four weeks one after another, with a two week break in between. The prepared, wasted as well as leftover food was weighed daily by the school kitchen staff during both pre and post optimization periods. School lunch satisfaction was assessed using an online questionnaire during both baseline period and intervention as well as slope differences in daily food waste were further noticed.

- *Inference:* The results showed a significant effect of optimization on GHGE levels, nutrition, and cost. Post intervention, the food list was 40% lower in GHGE. It

met all nutritional requirements of school meal recommendations and total cost reductions amounted to 11%.

The findings demonstrate that school meals can successfully be improved regarding health, cost and environmental sustainability using linear optimization, without negative effects on food waste, consumption, or satisfaction. This approach offers the necessary flexibility to tailor menus in different educational institutions to improve efficiency of learning.

#### 4. Conclusion

By optimizing the use of OR solutions within the educational sector one can pioneer its very future. With the advent of Data Envelopment Analysis (DEA) one will not only be able to accurately measure the relative efficiencies of these schools but can also consider the individual students, their strengths, and weaknesses, to effectively tailor the best choice for them. With the inception of goal programming, analysts will be able to come out with balanced solutions for school bus routing and scheduling. Moreover, optimization can be used for diet management to model school meals. And finally with integer programming, one can revamp the very foundation of the timetabling method to best ensure a seamless cohesion with student preferences, attention spans, alongside teacher availability and preferences. Education has always been a way forward for various socio-economic classes and its accessibility has been known to reduce crime rates, boost the local economy, and slash poverty. By leveraging OR analytics, and modern technological marvels one can make a lasting impact on the world.

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