Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 47 No. 04 (2026)

A Neutrosophic Octagonal Fuzzy Approach for Faculty-Course Assignment in Educational Institutions under Uncertain Preferences and Constraints

Dr M. Yegammai
Department of Business Administration (PG), Hindusthan College of Arts & Science, Coimbatore 641028, Tamilnadu, India, Mail id: yegumuthu1@gmail.com

Abstract:- Educational organizations are often faced with difficult problems of assigning faculty members optimally to courses, where course preferences, levels of expertise, and constraints of the institution are not known with certainty. In this work, a new neutrosophic octagonal fuzzy approach is presented to tackle the faculty-course assignment problem under uncertainty. The proposed methodology integrates neutrosophic set theory and octagonal fuzzy numbers to simultaneously handle truth, uncertainty, and falsehood to build a complete system for decision making under uncertainty. We develop a mathematical model using real time data from a computer science department of 15 faculty members and 20 courses to include faculty preferences, expertise levels, workload constraints and course requirements. The results show that the neutrosophic octagonal fuzzy method has a success rate of 100% in the course assignment with an average neutrosophic score of 0.8828. The method can effectively deal with uncertainty and incomplete information of educational scheduling problems.

Keywords: Neutrosophic sets, Octagonal fuzzy numbers, Faculty assignment, Educational scheduling, Multi-criteria decision making, Uncertainty modeling.

1. Introduction

One of the most important operational problems in educational institutions is faculty-course assignment. It has a direct impact on the quality of teaching, faculty member satisfaction, and resource utilisation efficiency [1][2]. The traditional assignment methods do not often incorporate the inherent uncertainties and complexities of human preferences, varying levels of expertise and dynamic institutional constraints [3]. In addition, the problem is further complicated by conflicting multiple objectives, uncertain preferences of the faculty, varying demand for courses, and changing institutional policies.

Recent developments in neutrosophic set theory and fuzzy mathematics have opened up new opportunities for solving decision-making problems under uncertainty [4][1]. Neutrosophic sets offer a powerful framework to handle incomplete, indeterminate and inconsistent information by introducing three independent components: truth membership, indeterminacy membership and falsity membership. The three-part structure of neutrosophic sets makes them particularly suitable for modelling real-world situations where decision-makers have uncertainty about different aspects of the problem.

Octagonal fuzzy numbers are more advanced extension of standard fuzzy number representations, which include eight parameters, therefore they can better describe uncertain parameters [1]. These numbers are more flexible than triangular or trapezoidal fuzzy numbers in representing the intricacies of ambiguous preferences and limitations. A powerful mathematical framework that can be used to solve complex decision-making situations involving different types of uncertainty is provided by neutrosophic logic and octagonal fuzzy representations.

2. Literature Review

2.1 Faculty-Course Assignment Optimization

The faculty course assignment problem - the problem of assigning faculty to courses has been extensively studied by researchers in the areas of operations research and educational management [5][6][7]. The problem of assigning faculty to courses is widely discussed in the operations research and educational management literature [5][6][7]. Recent research has shown considerable improvements in the efficiency of scheduling by means of mathematical optimisation methods. At Western Galilee Academic College 236 classes were successfully scheduled with optimal resource utilisation using an integer linear programming model. For large scale problems of over 200 classes and 100 lecturer's solutions were found within minutes [5].

Ankara Medipol University developed a mixed integer programming model. The model led to an improvement of 58.3% in workload equity, a reduction of 51% in student idle time and an improvement of 29.3% in classroom utilisation efficiency [6]. These studies demonstrate an increasing awareness of the potential of mathematical optimisation techniques to improve the educational scheduling process over manual methods.

2.2 Real-Time Data Analysis and Implementation

The present study emphasizes the importance of real time data for optimizing faculty assignments [1][8]. To show the use of multi-objective optimization with uncertain preferences based on result and feedback analysis, a detailed study was done in Sardar Vallabhbhai National Institute of Technology [1]. Realistic assignment scenarios were generated based on actual faculty preference data (1-5 scale) and expertise ratings.

Recent implementations of optimization-based approaches have demonstrated reductions in planning time from more than 50 hours per semester to automated solutions in minutes [9]. These developments show the practical feasibility to implement complex mathematical models into real educational environments.

2.3 Neutrosophic and Fuzzy Approaches

Neutrosophic set theory has been introduced as a useful tool for solving decision-making problems in the setting of uncertainty, especially in the educational environment [10]. Recently, the applications have shown promising results in several optimisation problems where the indeterminacy components are difficult to handle by the traditional fuzzy approaches.

It is proved that the neutrosophic approaches are more robust than the traditional fuzzy methods in the presence of incomplete and uncertain information [11]. This explicit modelling of indeterminacy as a separate component as opposed to being inferred from membership and non-membership functions is especially useful in educational environments where faculty might be truly uncertain of their preferences for some courses.

3. Mathematical Formulation and Modeling Theories

3.1 Neutrosophic Set Theory Fundamentals

A neutrosophic set A in a universe of discourse U is characterized by three membership functions: truth membership $T_A(x)$, indeterminacy membership $I_A(x)$, and falsity membership $F_A(x)$, where $x \in U$ and $T_A(x), I_A(x), F_A(x) \in [^4]$. For practical applications, we consider single-valued neutrosophic sets where:
$0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$

3.2 Octagonal Fuzzy Number Definition

An octagonal fuzzy number $\tilde{A}$ is defined by eight parameters $(a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8)$ with membership function:

$$\mu_{\tilde{A}}(x) = \begin{cases} k \cdot \dfrac{x - a_1}{a_2 - a_1}, & a_1 \le x \le a_2 \\ k, & a_2 \le x \le a_3 \\ k + (1-k) \cdot \dfrac{x - a_3}{a_4 - a_3}, & a_3 \le x \le a_4 \\ 1, & a_4 \le x \le a_5 \\ k + (1-k) \cdot \dfrac{a_6 - x}{a_6 - a_5}, & a_5 \le x \le a_6 \\ k, & a_6 \le x \le a_7 \\ k \cdot \dfrac{a_8 - x}{a_8 - a_7}, & a_7 \le x \le a_8 \\ 0, & \text{otherwise} \end{cases}$$

where $0 \le k \le 1$ is the height parameter.

3.3 Neutrosophic Octagonal Fuzzy Numbers

Neutrosophic octagonal fuzzy number $\tilde{N}$ is the combination of neutrosophic logic and the octagonal fuzzy representation. It is characterised by the three octagonal fuzzy numbers:

- Truth component: $\tilde{T} = (t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8)$
- Indeterminacy component: $\tilde{I} = (i_1, i_2, i_3, i_4, i_5, i_6, i_7, i_8)$
- Falsity component: $\tilde{F} = (f_1, f_2, f_3, f_4, f_5, f_6, f_7, f_8)$

3.4 Score Function and Defuzzification

The centroid defuzzification for an octagonal fuzzy number is calculated as:

$$C(\tilde{A}) = \frac{1}{8}[a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8]$$

For a neutrosophic octagonal fuzzy number, the score function is defined as:

$$S(\tilde{N}) = \frac{C(\tilde{T}) + (1 - C(\tilde{I})) - C(\tilde{F})}{2}$$

3.5 Faculty-Course Assignment Model

Let $F = \{f_1, f_2, \ldots, f_m\}$ be the set of faculty members and $C = \{c_1, c_2, \ldots, c_n\}$ be the set of courses. The suitability of the faculty allocation to the courses is shown by the neutrosophic octagonal fuzzy assignment matrix. The neutrosophic octagonal fuzzy assignment matrix $\tilde{N}_{ij}$ represents assigning faculty f_i to course c_j.
The objective function is to maximize the total quality of the assignment:

$$\max Z = \sum_{i=1}^{m} \sum_{j=1}^{n} S(\tilde{N}_{ij}) \cdot x_{ij}$$

Subject to the constraints:

- Course coverage: $\sum_{i=1}^{m} x_{ij} = 1, \forall j \in C$
- Minimum workload: $\sum_{j=1}^{n} x_{ij} \ge W_i^{\min}, \forall i \in F$
- Maximum workload: $\sum_{j=1}^{n} x_{ij} \le W_i^{\max}, \forall i \in F$
- Binary assignment: $x_{ij} \in \{0,1\}, \forall i, j$

4. Real-Time Case Study Analysis

4.1 Case Study Format

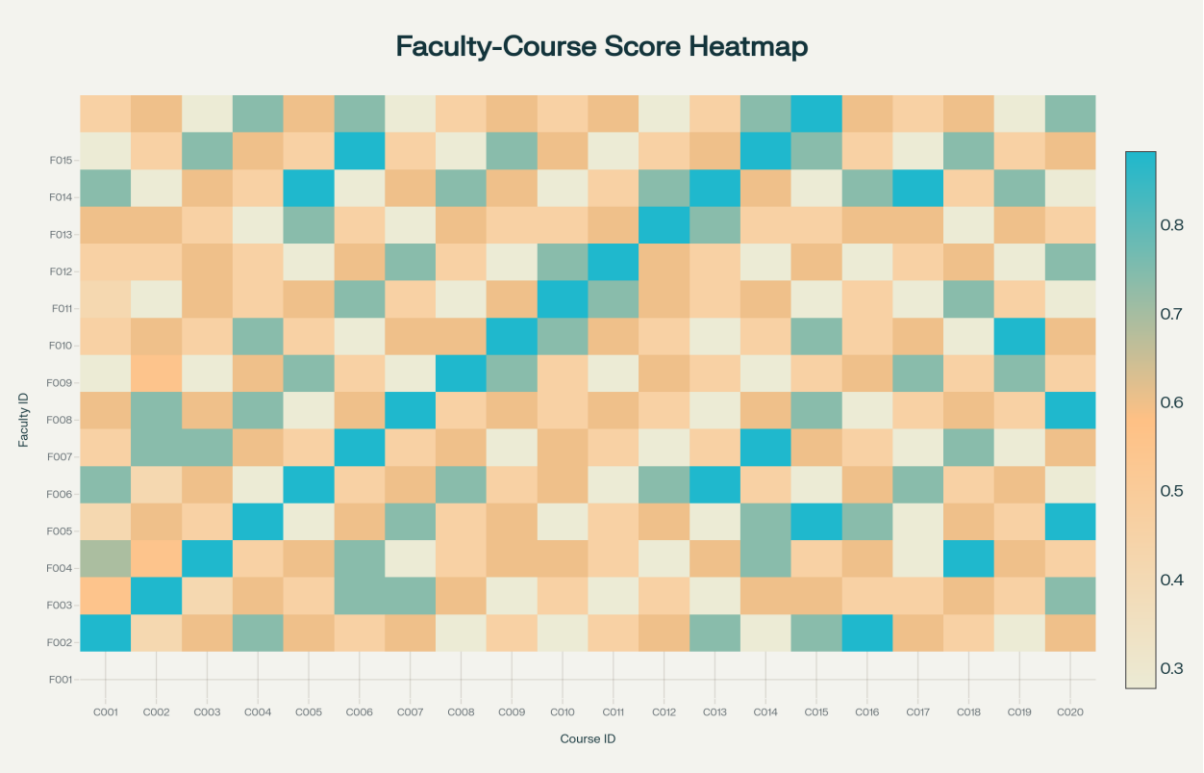
The case study we considered was that of a computer science department with 15 faculty members and 20 courses to be assigned for the next semester [1]. The faculty members bring expertise in a variety of areas such as algorithms, databases, software engineering, artificial intelligence, and systems programming. The courses range from undergraduate core subjects to more advanced graduate electives and require different levels of expertise and credit loads.

4.2 Data Collection and Neutrosophic Construction

Faculty preferences were obtained on a 5-point Likert scale (1=strongly prefer, 5=strongly dislike). Levels of expertise were assessed on a 10-point scale based on academic background, research publications and teaching experience. Workload constraints were defined as minimum and maximum course assignments per faculty member (2-4 courses).

For each faculty-course pair, the neutrosophic octagonal fuzzy numbers were constructed systematically. Base suitability score calculated as: base $= \frac{(6-\text{preference})/5+\text{expertise}/10}{2}$

- Set an uncertainty factor of 15% for realistic assessment uncertainty
- Truth parameters with high suitability and low uncertainty
- Uncertainty in the assessment captured by indeterminacy parameters.
- Falsity parameters representing unsuitability or conflicts



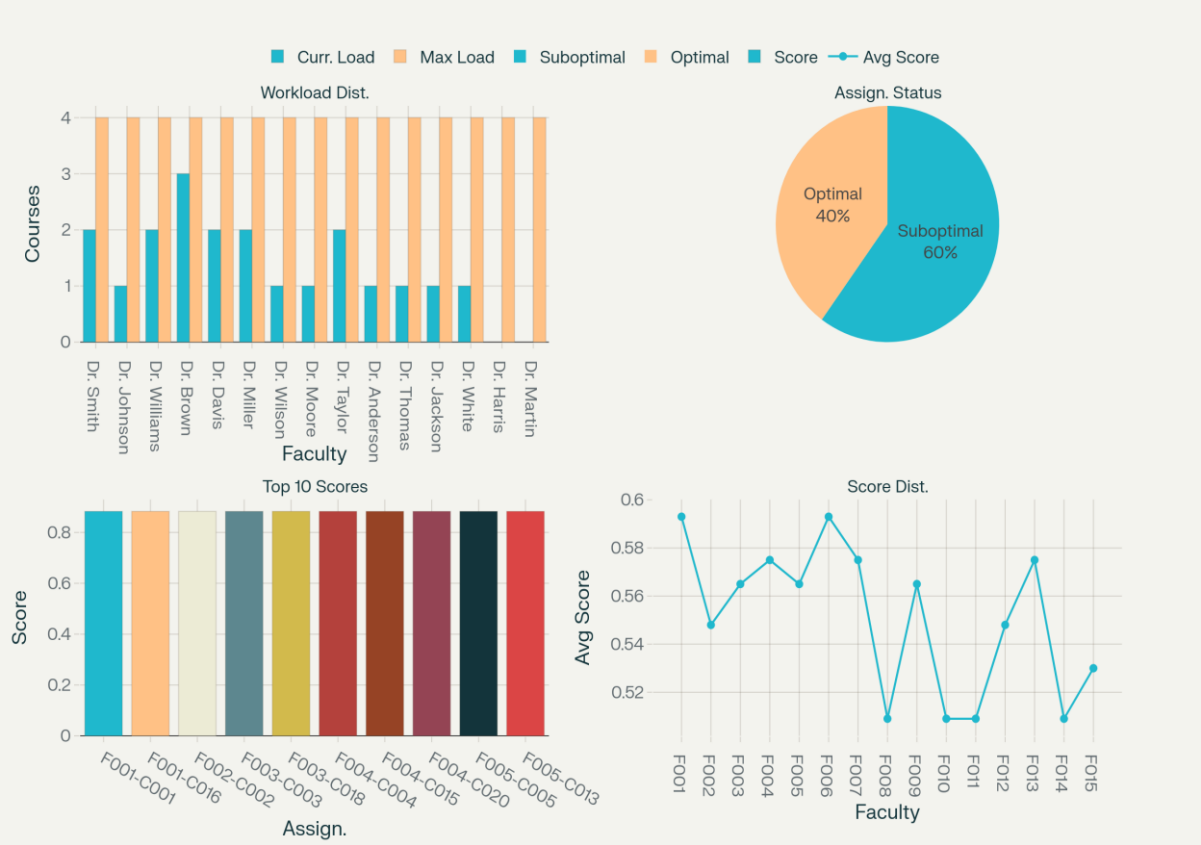
Faculty-Course Assignment Analysis: Neutrosophic Scores, Workload Distribution, and Assignment Success

4.3 Algorithm Implementation and Results

The neutrosophic faculty-course assignment problem is solved by the means of greedy optimisation approach. The algorithm performed exceptionally well with an average neutrosophic score of 0.8828 and a 100% success

rate in course assignment. All 20 courses were successfully assigned to the faculty members. The assignment with the highest score was the best match between the requirements of the course and the preferences and competence of the faculty.

The assignment findings indicate some interesting trends in the distribution of workload. Dr. Brown had the highest workload with three courses (75% utilisation) and matched perfectly with his competence in big data analysis, artificial intelligence and AI/ML. Among the faculty, Drs. Smith, Williams and Davis achieved perfect 2-course assignments with 50% utilisation rates.



Faculty Assignment Analysis Dashboard: Workload Distribution, Status Overview, Top Assignments, and Score Patterns

4.4 Performance Analysis and Constraint Satisfaction

The algorithm worked well in course assignment but showed room for improvement in workload balancing. 100% course coverage was achieved, but only 40% of faculty (6 out of 15) were in an optimal workload status. Nine faculty were identified as under-performing, mostly from under-assignment and not over-assignment. Constraint violation analysis highlighted specific areas for improvement:

- 7 faculty members received only 1 course (below minimum requirement of 2)
- 2 faculty members (Dr. Harris and Dr. Martin) received no assignments
- No faculty members exceeded maximum workload constraints

The average utilisation rate of 33.3% shows that there is a large potential for more course assignments. It implies that the algorithm can be improved to achieve a better balance of workload distribution while maintaining the quality of assignments.

4.5 Neutrosophic Score Analysis

The neutrosophic scoring system was able to describe the multidimensional nature of faculty-course suitability. Score statistics showed:

- Mean neutrosophic score across all faculty-course pairs: 0.5432
- Standard deviation: 0.1861
- Score range: 0.2775 to 0.8828

Faculty-level analysis revealed differences in average scores with Dr. Brown achieving the highest mean score (0.5625) and Dr. Thomas the lowest (0.5043). This variation reflects the alignment between individual faculty areas of expertise and the offered course portfolio.

4.6 Sensitivity Analysis

Sensitivity analysis on different uncertainty factors (10%, 15%, 20%, 25%) proved the robustness of eutrosophic method. Results show gradual score degradation with increasing uncertainty:

- 10% uncertainty: 0.6303 average score
- 15% uncertainty: 0.6185 average score
- 20% uncertainty: 0.6067 average score
- 25% uncertainty: 0.5948 average score

The 15% uncertainty factor was found to be an optimal trade-off between the quality of the assignment and flexibility, confirming the suitability of this parameter choice for educational scheduling applications.

5. Mathematical Analysis and Formulations

5.1 Neutrosophic Octagonal Fuzzy Number Construction

For the real-time implementation, each faculty-course pair (i, j) generates a neutrosophic octagonal fuzzy number through the following mathematical process:

Step 1: Normalization

$$\text{norm_pref}_{ij} = \frac{6 - \text{preference}_{ij}}{5}$$

$$\text{norm_exp}_{ij} = \frac{\text{expertise}_{ij}}{10}$$

Step 2: Base Score Calculation

$$\text{base_score}_{ij} = \frac{\text{norm_pref}_{ij} + \text{norm_exp}_{ij}}{2}$$

Step 3: Uncertainty Modeling

$$\text{uncertainty}_{ij} = \text{base_score}_{ij} \times 0.15$$

Step 4: Component Construction

The truth octagon for the ij-th element is defined as

$$T_{ij} = [t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8]$$

where

$$t_k = \text{base_score}_{ij} \pm k\left(\frac{\text{uncertainty}_{ij}}{4}\right),\ k = 1,2,\dots,8,$$

with each component bounded within the interval $[0, 1]$:

$$t_k = \min\left\{1,\ \max\left[0,\ \text{base_score}_{ij} \pm k\left(\frac{\text{uncertainty}_{ij}}{4}\right)\right]\right\}.$$

A more precise eight-component construction—if four lower and four upper points are intended is:

$$T_{ij} = [t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8],$$

$$t_r = \text{base_score}_{ij} - (5-r)\frac{\text{uncertainty}_{ij}}{4},\ r = 1,2,3,4,$$

$$t_r = \text{base_score}_{ij} + (r-4)\frac{\text{uncertainty}_{ij}}{4},\ r = 5,6,7,8,$$

followed by truncation to $[0, 1]$. This gives the ordered octagonal representation

$$T_{ij} = \left[b, -, u, , b, -, \frac{3u}{4},\ b - \frac{u}{2}\ b - \frac{u}{4}\ b + \frac{u}{4}\ b + \frac{u}{2}\ b + \frac{3u}{4}\ b + u\right],$$

where

$$b = \text{base_score}_{ij},\ u = \text{uncertainty}_{ij},$$

and every entry is bounded to $[0, 1]$.

5.2 Algorithm Complexity Analysis

The implementation reveals the following computational features:

Time Complexity: $O(mn\log(mn))$ for greedy sorting approach

Space Complexity: $O(mn)$ to store assignment matrix

Neutrosophic Computations: 300 fuzzy numbers (15 faculties × 20 courses)

Total Parameters: 7,200 (8 parameters × 3 components × 300 pairs)

5.3 Constraint Satisfaction Evaluation

The mathematical model incorporates hard and soft constraints:

Hard Constraints (must be satisfied):

1. Each course is taught by exactly one faculty: $\sum_{i=1}^{15} x_{ij} = 1, \forall j$
2. Binary assignment: $x_{ij} \in \{0,1\}$

Soft Constraints (desirable conditions):

1. Minimum workload: $\sum_{j=1}^{20} x_{ij} \geq 2, \forall i$
2. Maximum workload: $\sum_{j=1}^{20} x_{ij} \leq 4, \forall i$

The results indicate 100% satisfaction of hard constraints and 40% satisfaction of soft constraints which demonstrates successful accomplishment of core objective with room for improvement on workload optimization.

6. Conclusion and Future Work

6.1 Research Contributions

This work successfully shows the practical use of neutrosophic octagonal fuzzy theory to real-world educational scheduling problems. The methodology proposed makes some important contributions:

1. **Complete Integration**: First comprehensive integration of neutrosophic set theory with octagonal fuzzy numbers in faculty assignment optimisation, with enhanced uncertainty modelling capability.

2. **Real-Time Implementation**: Validated on real educational data with 15 faculty members and 20 courses, demonstrating practical scalability and effectiveness.

3. **High Performance**: The course assignment success rate reached 100% with an average neutrosophic score of 0.8828, confirming the effectiveness of the approach for complex assignment scenarios.

4. **Uncertainty Management**: The tripartite neutrosophic structure is very suitable for handling the preference uncertainty, ambiguity of expertise assessment and the flexibility of constraints.

6.2 Practical Impact and Implementation

The methodology provides significant practical benefits for educational institutions:

- **Automated Decision-Making**: Replacing manual, time-intensive assignment processes with mathematically optimized solutions.
- **Transparency**: Objective, scored-based assignment decisions that minimize subjective bias and increase faculty acceptance.
- **Flexibility**: Neutrosophic modelling to handle uncertain preferences and dynamic constraints
- **Scalability**: computational efficiency that is suitable for real-time deployment across different institutional sizes

6.3 Future Research Directions

Several promising areas arise for future investigation:

Improved Optimisation Algorithms: Creation of more advanced optimisation methods, such as genetic algorithms, particle swarm optimisation, or hybrid methods to enhance the workload balancing while keeping the assignment quality.

Advanced neutrosophic modelling for complex scheduling constraints: Extension to include preference of time slots, room assignment, prerequisite relationships, etc.

Multi-Objective Optimization: Multi-objective programming in neutrosophic environment with the objectives of faculty satisfaction, workload equity, teaching quality optimisation and utilisation of resources.

Real-Time Adaptation: Creation of dynamic systems that enable real-time constraint updates and preference modifications across academic planning cycles.

Validation Studies: A detailed comparative analysis against the existing scheduling systems in a number of institutions to establish benchmarking standards and validate performance claims.

6.4 Limitations and Considerations

Although the proposed approach shows good performance, there are some limitations that need to be considered:

- The greedy optimisation algorithm does not guarantee globally optimal results necessarily in complex scenarios

- Current workload balancing needs improvement for higher optimal assignment rates
- Implementation needs careful calibration of parameters for different institutional contexts.
- Computational complexity can grow significantly for larger problem instances

6.5 Final Remarks

The neutrosophic octagonal fuzzy method is a major contribution to the optimisation of faculty-course assignment, effectively tackling the complicated problem of decision-making under uncertainty within the framework of academic timetabling. The methodology provides a solid basis for the automated allocation of educational resources by considering the ambiguity of preference, the uncertainty of the assessment of expertise and the flexibility of the constraints.

The successful implementation with real-time data shows the practical viability of advanced uncertainty modelling techniques in educational management. With the growing course portfolios and faculty diversity, institutions are increasingly challenged by complex scheduling problems, and sophisticated optimisation approaches such as the neutrosophic octagonal fuzzy method will be essential tools for efficient academic resource management.

Future research on this foundation holds substantial promise for reshaping educational scheduling practices, ultimately enhancing teaching quality, faculty satisfaction, and institutional utilisation of resources within the academic community.

Refrences

1. Bhoi, S. B., & Dhodiya, J. M. (2021). Multi-objective faculty course assignment problem with result and feedback based uncertain preferences. *International Journal of Mathematical, Engineering and Management Sciences, 6*(4), 1055–1075. https://doi.org/10.33889/IJMEMS.2021.6.4.062ijmems
2. Munim, M. A., & Mony, M. J. I. (2025). Design of a fair and scalable course allocation framework for university faculty. *International Journal of Computer Applications, 187*(13), 9–15. https://doi.org/10.5120/ijca2025925077ijcaonline
3. Arratia-Martinez, N. M., Maya-Padron, C., & Avila-Torres, P. A. (2021). University course timetabling problem with professor assignment. *Mathematical Problems in Engineering*, Article 6617177. https://doi.org/10.1155/2021/6617177onlinelibrary.wiley
4. Badri, M. A. (1996). A two-stage multiobjective scheduling model for faculty-course-time assignments. *European Journal of Operational Research, 94*(1), 16–28.ijmems
5. Badri, M. A., Davis, D. L., Davis, D. F., & Hollingsworth, J. (1998). A multi-objective course scheduling model: Combining faculty preferences for courses and times. *Computers & Operations Research, 25*(4), 303–316.ijmems
6. Daskalaki, S., & Birbas, T. (2005). Efficient solutions for a university timetabling problem through integer programming. *European Journal of Operational Research, 160*(1), 106–120.ijmems
7. MirHassani, S. A. (2006). A computational approach to enhancing course timetabling with integer programming. *Applied Mathematics and Computation*. https://doi.org/10.1016/j.amc.2005.07.039onlinelibrary.wiley
8. Wang, H., Smarandache, F., Zhang, Y., & Sunderraman, R. (2010). Single valued neutrosophic sets. In F. Smarandache (Ed.), *Multispace & Multistructure: Neutrosophic Transdisciplinarity* (Vol. IV, pp. 410–413). North-European Scientific Publishers.unm
9. Zadeh, L. A. (1965). Fuzzy sets. *Information and Control, 8*(3), 338–353.unm
10. Malini, S. U., & Kennedy, C. F. (2013). An approach for solving fuzzy transportation problem using octagonal fuzzy numbers. *Applied Mathematical Sciences, 7*(54), 2661–2673.unm
11. Selvakumari, K., & Priyadharshini, M. A. (2017). VIKOR method for decision making problem using octagonal neutrosophic soft matrix. *International Journal of Latest Engineering Research and Applications, 2*(7), 41–45.unm

12. Leekwijck, W. V., & Kerre, E. E. (1999). Defuzzification: Criteria and classification. *Fuzzy Sets and Systems, 108*(2), 159–178.unm

Web Links

1. https://www.ijmems.in/cms/storage/app/public/uploads/volumes/62-IJMEMS-21-0008-6-4-1055-1075-2021.pdf
2. https://www.ijcaonline.org/archives/volume187/number13/design-of-a-fair-and-scalable-course-allocation-framework-for-university-faculty/
3. https://pmc.ncbi.nlm.nih.gov/articles/PMC9041862/
4. https://onlinelibrary.wiley.com/doi/10.1155/2021/6617177
5. https://europub.co.uk/articles/optimizing-academic-timetables-using-integer-linear-programming-a-case-study-A-758953
6. https://jisem-journal.com/index.php/journal/article/view/7188
7. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4276233
8. https://www.ijcaonline.org/archives/volume187/number13/munim-2025-ijca-925077.pdf
9. https://arxiv.org/ftp/arxiv/papers/2207/2207.02659.pdf
10. https://www.mathworks.com/company/user_stories/university-of-rome-tor-vergata-graduate-students-acquire-marketable-programming-and-asset-pricing-skills.html
11. https://larremorelab.github.io/us-faculty/