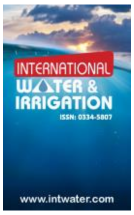

International Water and Irrigation
Volume 44 Issue 2 (2025)
ISSN: 0334-5807
Pages 116 - 124

Construction of Children's Education Evaluation System Based on Fuzzy Logic

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Abstract: Preschool education is a complicated matter that requires a detailed analysis of many ecological and developmental factors. The existing approaches to educational evaluation lack consideration for the unpredictability bias associated with assessing children's learning and growth. The purpose of this project is to create an improved fuzzy logic (IFL)-based system for evaluating children’s education. For the children’s education assessment system, we collected the various preschool data samples. Physical, socio-emotional development, spiritual, and intellectual growth, parental participation, care, behavior control, and attendance are the seven main feature areas that are the focus of the examination. After the data collection, min-max normalization is employed, to preprocess the data. Principal component analysis (PCA) is performed to remove the irrelevant features, to identify major features. These inputs are translated into fuzzy sets and evaluated using a fuzzy inference system. A prototype of the system is implemented and tested with a dataset of children's educational records. An education evaluation system based on fuzzy logic improves traditional methods by addressing vagueness and subjectivity in assessments. This comprehensive and accurate evaluation enhances in preschool educational strategies and preschool children performance analysis interventions, leading to better outcomes for preschool children.

Keywords: Improved Fuzzy Logic (IFL), Principal Component Analysis (PCA), Preschool, Children's Education, Development.

1. Introduction

The creation of human capital in later life is influenced by instances throughout childhood. Worldwide pre-primary enrollment rates are rising, but their sustainability is in contradiction, particularly in large-scale settings [1]. Preschool education is crucial for quality education as it initiates lifelong learning and offers educational resources for children of their age group. Facilities quality and accessibility are essential, particularly for middle-class, lower-class, and high-income communities. Thus, it is essential to consideration the benefits of early childhood development. The platform for preschool education resources has fully merged content practicality and resource diversity, as well as maximized the integration of preschool education resources [2]. However, preschool education remains an inadequate component in all levels and types of schooling, driven by establishments and differential growth in urban and rural regions. High-quality preschool teaching materials are rather restricted, and the development of collective nursery schooling wealth remains in its infancy [3]. To encourage the common application of excellent learning property, the schooling sector has fully incorporated the idea of digital networks into the field of preschool teaching source allocation [4]. Construction-related activities are a common feature of preschool technology themes, which could assist children learn about technology and equipment used in building. Involvement in real-world activities can facilitate the discussion of problem-solving techniques. While it could not be considered a necessary life skill, learning to combine recyclable materials can offer possibilities to experiment with different approaches [5]. Children can learn more about ordinary objects and technical operations with a modest construction endeavor. In the past 25 years, the number of preschools has increased, in past two years with an emphasis on teacher-led instruction. Prior research has emphasized the significance of teacher-led instruction in fostering children's building abilities and technological comprehension. Preschool instructors and

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daycare providers, frequently consider their responsibilities as supplying resources and fostering a creative atmosphere for children rather than guiding and assisting them [6]. In teacher-led learning, the student interacts with the material, drawing on their prior knowledge and experience. It indicates that a child's exposure to and understanding of technology during preschool can have a significant influence and interact with their instructor [7]. From a user and design perspective, providing children immediate access to user assistance for various resources and tools could assist them to become more confident with technology. The study aims to incorporate Fuzzy Logic into a Children's Education Evaluation System, providing a robust framework for effective performance and adapted intervention.

The rest of the paper is given below: Section 2 determined the related work of the study. Section 3 depicts the methods and materials and the result are described in section 4. Final section concludes the study.

2. Related Works

Preschool remote education course features were examined and their score characteristics were calculated in [8]. Based on the user's choices and the similarity matrix, it forecasts their assessments. Using the shortest path between phrases and user interest in preschool distance learning courses completes the collaborative filtering process. To produce the finest suggestions for preschool education, the list of ideas was projected based on user preferences. Based on experimental data, the suggested technique has an RMSE of 0.95, with over 80% recommended accuracy and up to 99% maximum accuracy. A matrix paradigm for the high-quality allocation of preschool instructional capital among students was provided in [9]. The model takes advantage of shared resource matrix analysis to ensure the implicit exchange of data and symmetry. The distinction between resources and noise data elements is strengthened with the K-nearest neighbor (KNN) search technique. Preschool education resource sharing sequence and timing are optimally determined using the ant colony particle swarm optimization (AC-PSO) technique. The atmosphere concept eliminates variability in resources and offers effective interactive technological assistance for building a platform for sharing resources for preschool education. Using the context input process and product (CIPP) paradigm from Stufflebeam, study [10] evaluated a preschool curriculum. The 2019–2020 academic period featured the collection of quantitative data from 122 preschool instructors working in public or private schools, and qualitative analysis via online conversations with ten teachers. Semi-structured interview forms and the preschool education program evaluation scale were employed as data-gathering instruments. The study demonstrated that instructors, who identified low physical qualities and equipment for pre-school instruction, had the greatest amount of unfavorable evaluations in the context dimension. The relational structure of preschool practice and how children's places are created within it were examined in [11]. It examines three occurrences a Finnish preschool through the lenses of relational sociology and ethnography.

According to the researchers, relationships were a part of every ethnographic event, and studying relationships that recurrent can assist identifying an established structure of the organization. The examination shows how a child's equilibrium is organized in routine preschool activities. The significance of a child's personality developing holistically and harmoniously in preschool education was covered in [12]. It recognized the difficulty in determining the physical and mental developments of preschoolers were coordinated. A method for evaluating preschoolers between the ages of five and six years old in terms of their ratio of mental to physical development is explained. However, when paired with physical education, motor exercise promotes more fruitful brain growth. It proves difficult to measure the correlations between mental and physical growth since there are no particular markers for quantitative harmony. Furthermore, correlation coefficients, which range from 0.03 to 0.394, cannot yield comparable indications of harmonization. Children's learning, growth, and social interaction all benefit greatly from outdoor play [13]. It indicates that the strategy is utilized in Greek preschool settings to an investigation conducted in 2019, kindergarten teachers, both past and present, value outdoor play and encourage the use of natural materials in the classroom. They frequently overlook the utilization of outdoor spaces for structured play activities, and prospective teachers occasionally assess play equipment on school grounds or products.

To balance the qualities of the students through assessment, study [14] utilized matrix laboratory (MATLAB) software to examine student performance utilizing fuzzy logic evaluation methods. An expert system built using the Mamdani approach was evaluated using grades from actual students. The findings provided the explanations for weaknesses in personality and academic growth, enabling a more methodical examination of student performance. There were difficulties with fuzzy clustering algorithms when studying hierarchy and accountable persons [15]. An improved fuzzy algorithm based on composite components is proposed in educational detection systems. To develop a smart campus academic early warning system that would facilitate student completion and assist with decision-making. The research focuses on early warning model research and system design, and the results indicate that the algorithm enhancement has the best model evaluation impact, with precision (78.96%), AUC at 80.25%, and recall (85%).

3. Methods and Materials

In this section, this study gather a dataset among three different preschools to highlight distinct feature aspects, and min-max normalizations are used to preprocess the collected data. To eliminate or remove the irrelevant features by using principal component analysis (PCA) these inputs are translated into fuzzy sets and evaluated using a fuzzy inference system. Figure 1 shows the flow of methodology.

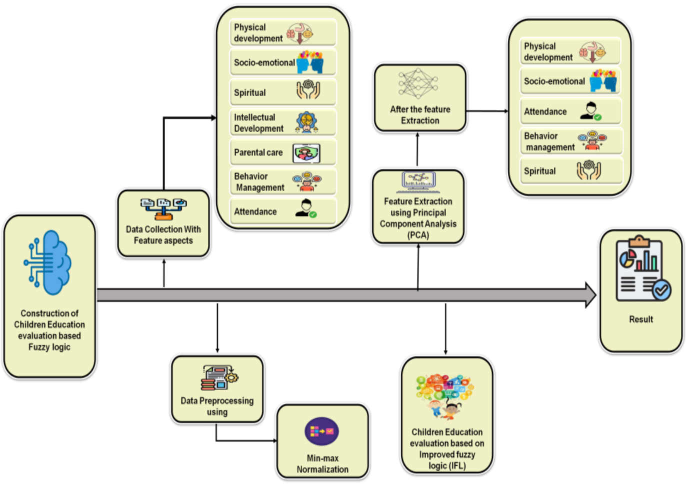


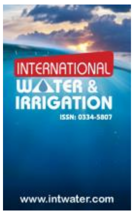
Figure 1: Overview Of the Proposed Method

3.1 Dataset

We gather a dataset among three different preschools (Preschool A, Preschool B, and Preschool C). In the preschool A there are 10 male and 18 female children, Preschool B maintains 12 male and 16 female children, and Preschool C maintains 13 male children and 22 female children to highlighting distinct feature aspects: physical development, socio-emotional, spiritual, and intellectual development, alongside parental care and involvement, behavior management, and attendance of the preschool children, Table 1 briefly explained the following feature aspect.

Table 1: Features And Description of Preschool Data Samples

Feature Aspect	**Preschool A**	**Preschool B**	**Preschool C**
Physical Development	Emphasizes outdoor activities; and structured physical education programs.	Focuses on gross motor skills; playground equipment and sports activities.	Provides daily exercise routines; yoga and dance sessions.



Socio-emotional Development	Uses social games and role-playing to foster empathy and cooperation.	Implements conflict resolution strategies; promotes emotional literacy.	Integrates mindfulness practices; emphasizes emotional expression.
Spiritual Development	Incorporates nature walks and discussions about the environment.	Includes storytelling with moral lessons; and cultural and religious celebrations.	Encourages meditation and reflection; explores values and ethics.
Intellectual Development	Science, Technology, Engineering, and Mathematics (STEM)-focused learning; hands-on experiments and problem-solving tasks.	Language-rich environment; literacy activities and early reading programs.	Cognitive puzzles and logic games; creative arts and critical thinking exercises.
Parental Care and Involvement	Regular parent-teacher meetings; workshops on child development.	Open-door policy; parent volunteer opportunities in classrooms.	Parent education sessions; involvement in school events and projects.
Behavior Management	Positive reinforcement techniques; clear expectations and routines.	Consistent discipline strategies; behavior charts and reward systems.	Individualized behavior plans; collaborative approach with parents.
Attendance	High attendance rate; proactive communication with parents regarding absences.	Monitors attendance closely; follows up with absentee families promptly.	Encourages punctuality; tracks attendance trends for intervention.

3.2 Data preprocessing using Min-max normalization

After collecting the data samples, it was cleaned by eliminating noise and compressing it, followed by preprocessing through feature scaling and normalization. The value significance is demonstrated by reducing the minimum value, and the data's duration was extended through the usage of a special augmentation model. The last step in the data combination procedure is data preparation. Processing of the min-max normalization is an essential phase in the data normalization and integration operations. The minimum and maximum values of the characteristic variable are 0 and 1, respectively. Equation (1) illustrates a demonstration of the normalization process. Assume that intend to employ Min-Max scaling to scale the original digestive system data, which is Y_{scaled}, to produce the transformed data, Y_{scaled}.

$$Y_{scaled} = \frac{Y - Min_y}{Max_y - Min_y} \quad (1)$$

The following is the Min-Max scaling formula for each feature vector intensity Y inY, Y_{scaled} is the initial feature's increased value. Min_y Is the minimal value of the feature for the whole dataset. Max_y Is a representation of the feature's greatest value over the whole Y_{scaled}. By using this preprocessing, the data effectively remove the unwanted missing data.

3.3 Feature Extraction using Principal Component Analysis (PCA)

After preprocessing the data, PCA is used to extract the features. The fundamental idea underlying PCA was to construct an altered linear order for the actual data that had particular related qualities. As a consequence, a collection of unique information with few characteristics was added to the principal component load (PCL)

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atmosphere to represent the real in order. It works well for the multidimensional reduction of the production of complexity for IoT data in healthcare. Make a structure of observations Y using real data. Following m observations, the matrix Y is determined by the w variables $\theta_1, \theta_2, \ldots, \theta_x$. The representative data included in the set of values, estimated numerically is represented by each row, and the quantity in a feature indicates the total number of samplings that were located.

$$Y = \begin{bmatrix} Y_{11} & Y_{12} & \cdots & Y_{1w} \\ Y_{21} & Y_{22} & \cdots & Y_{2w} \\ \vdots & \vdots & \ddots & \vdots \\ Y_{m1} & Y_{m2} & \cdots & Y_{mw} \end{bmatrix} \quad (2)$$

To see the matrix, data processing should be centralized. Additionally, it determine the sample mean represents in equation (3) and the Standard deviation shown in equation (4).

$$\overline{y_a} = \frac{1}{n} \sum_{b=1}^{m} y_{ba} \quad (3)$$

$$T_a = \sqrt{\frac{1}{n} (y_{ba} - \overline{y_a})^2} \quad (4)$$

Applying the PCL matrices, create a linear change for the real data $K^S_{w\times o}$ and Equation (5), to create additional significant factors$x_1, x_2, \ldots, x_q$.

$$\begin{bmatrix} x_1 \\ \vdots \\ x_o \end{bmatrix} = K^S_{w\times o} \begin{bmatrix} \theta_1 \\ \vdots \\ \theta_o \end{bmatrix} \quad (5)$$

The matrix's proportions shifted from X to Q after the linear adjustment, greatly lowering the amount of information that could be retrieved. After extracting the features, the five most crucial feature elements Physical, socio-emotional development, Spiritual Development, care, behavior control, and attendance are assembled and transferred to the next phases.

3.4 Children's Education Evaluation based on Improved Fuzzy Logic (IFL)

In the construction of preschool children education evaluation the five major features are implemented by the improved fuzzy logic (IFL). The capability and skills of the pupils are also assessed using fuzzy logic. The most significant goal of creating a fuzzy model is to evaluate the knowledge and abilities of the student group, including their comprehension of problem-solving techniques and their capacity for analogical reasoning. The majority of technical skills are assessed based on pupils perform. Because of this, applying a fuzzy model can offer a useful method that is ambiguous and unpredictable. It's crucial to use fuzzy logic approaches while assessing the performance of the students. This approach is typically contrasted with the traditional evaluating method when assessing innovative performances. Through mathematical computations, this strategy may generate several preferences that are both flexible and stable by utilizing IFL. The purpose of the research is to determine students' performance utilizing the IFL model in conjunction with the traditional assessment approach. As a result, it is appropriate for use in laboratories as well as for assessing conceptual lessons. A membership function in fuzzy set P of the universal set U may be characterized as below, and the U denotes the universal set $U = \{w_1, w_2, w_3, \ldots w_n\}$. Equation (6) shows that the fuzzy collection P'smembership value is $\mu_{p(w)} \in [0,1]$ and P is a fuzzy subset of$w$.

$$P = \{(y, \mu_{p(w)} | w \in U)\} \quad (6)$$

Assume that the $set\ U$ contains two fuzzy sets, P and$Q$, equation (7) may be used to define the union of the fuzzy sets P and$Q$. Equation (8) may be used to define the intersection of the fuzzy sets P and$Q$, where $\mu_p\ and\ \mu_q$ are the relative membership aspects of the fuzzy sets P and Q;$\mu_p\ and\ \mu_q : U[0,1]$.

$$\mu_{pq(w)} = Max(\mu_{p(w)}, \mu_{q(w)}) \quad (7)$$

$$\mu_{pq(w)} = Min(\mu_{p(w)}, \mu_{q(w)}) \quad (8)$$

The membership function is used to separate the input and output parameters into distinct ranges. The membership function of a fuzzy set is an extension of the indicator function in classical sets, expressing the degree of truth in fuzzy logic. Although they are theoretically different, probabilities and degrees of truth have been interpreted because fuzzy truth is the representation of membership in ill-defined sets. As a result, percentages were used to represent the ranges of physical development, spiritual, socio-emotional, behavior management and Attendance.

IFL is a suitable method for constructing the evaluation of children's preschool education. There are four segments that constitute an IFL. These are referred as rules, inference engines, defuzzifiers (defuzzification), and fuzzifiers (fuzzification). Figure 2 displays the overall IFL architecture.

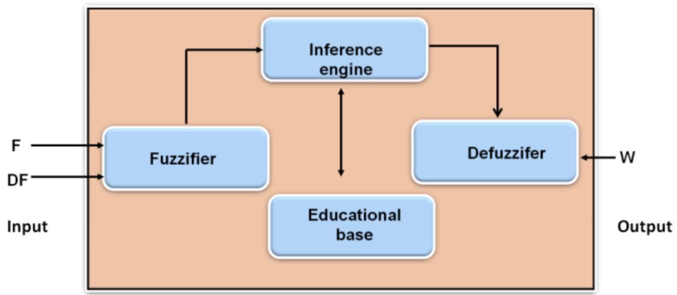

Figure 2: Architecture of IFL

3.4.1 *Rules and Fuzzy inference system (FIS)*

The input and output of the membership functions used in the inference process should be determined by the rules described in equation (9). These syntax conventions take the form of (If-Then) statements and can be presented flexibly based on the weight assigned by the academic experts. An explanation of the module's attributes, the initial stage is essential for selecting the number of inputs and outputs and to identify the fuzzy location. Using rules to analyze input vector values and apply them to output vectors, fuzzy logic is a technique for handling uncertainty. It entails employing fuzzy logic operators, membership functions, and If-Then rules to create a mapping from input to output. The degree to which an element belongs to a fuzzy set is determined by membership functions. Because fuzzy logic reasoning is a superset of conventional Boolean logic, regular logical processes hold if fuzzy values are maintained at their extremes of 0 and 1. This method substitutes min (A, B), max (A, B), and 1-A operators for the A AND, A OR, and NOT operators.

$$w_j = MIN\left[\mu_f(F), \mu_{df}(DF)\right] \quad (9)$$

3.4.2 *Fuzzifiers*

The process of converting an accurate scalar value into a fuzzy value is called fuzziness. The membership values are ascertained using the captured values. The Fuzzification inputs produced by this process are Average (AVG) with an interval of 0 to 30. Median (M) with the interval of 25 to 50, and High (H) with the interval of 45 to 75, excellent (EX) with the interval of 75 to 100.

3.4.3 *Defuzzifiers*

The output of an alternative problem requires in apparent quantity. Thus, the hazy set has to be reduced to a crisp set, which is a single integer value. This critical amount is a procedure known as defuzzification. To determine the often used defuzzification technique, the centroid approach, is applied at the middle of the defuzzification field. The defuzzifiers output is Highly Ineffective (HI) with an interval of (0, 0, 0.25), Ineffective (IE) with an interval of (0, 0, 25, 0.50). An effective (E) interval of (0.25, 0.50, 0.75) and Highly Effective (HE) with the interval of (0.50, 0.75, 1.0).

$$P = \frac{\sum_{j=1}^{m} x_j . v_j}{\sum_{j=1}^{m} x_j}, \tag{10}$$

The process of transforming the number that results from the decision-making process into a precise value is called defuzzification. The centroid approach, which is most used defuzzification technique to determine the center of the defuzzification region.

4. Results

In this section, we evaluate the gender-wise comparison of preschool children, and performance score for feature aspects.

4.1 Evaluation of preschool performance

The purpose of this study is to determine which preschool performs best and has the highest standard of preschoolers, with comparing the three preschools. The performance of ten preschoolers from the chosen schools is displayed in Table 2 as previously observed.

Table 2: Performance Of Preschool

S.No	Preschool A	Preschool B	Preschool C
1	IE	E	HE
2	E	E	E
3	HE	IE	HE
4	IE	HE	IE
5	HE	HE	HE
6	IE	HE	IE
7	IE	HE	HE
8	HE	IE	HE
9	HE	E	HE
10	HE	IE	HE

4.2 Gender-Wise Comparison of Preschool Children

The performance evaluation of preschool children shows that females consistently score higher than males across three preschools, which are described in Figure 3. In Preschool A, females achieve an 82% performance score compared to 76% for males. Similarly, in Preschool B, females score 77%, while males score 67%. In Preschool C, females attain a 75% performance score, outpacing the males who score 65%. Table 3 describes the data which indicates a trend where female preschoolers outperform their male counterparts in performance evaluations across different preschools.

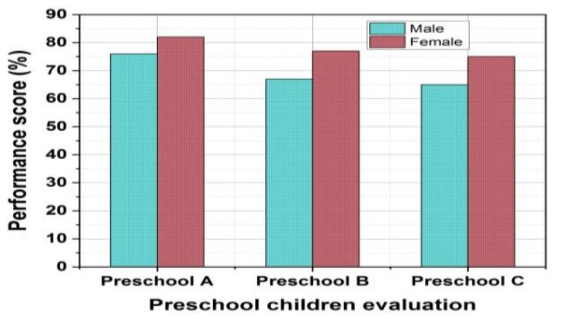

Figure 3: Comparison Of Preschool Children

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Table 3: Evaluation Of Preschool Children

Preschool children evaluation	Performance score (%)	
	Male	Female
Preschool A	76	82
Preschool B	67	77
Preschool C	65	75

4.3 Performance score for feature aspects

Table 4 compares performance scores across three preschools in various developmental aspects. Preschool C performs constantly well, achieving the highest scores in physical development which includes exercise, and dance (93%), behavior management like Quiet and Energetic (94%), and attendance which determined punctuality (97%). Preschool A shows strong performances in socio-emotional development like sports and emotional well-being (92%) and behavior management (89%), but slightly lower in spiritual development like yoga (83%). Preschool B performs well across all categories, with its highest score in attendance (92%) and lowest in spiritual development (75%). The overall figure is shown in Figure 4, where Preschool C dominates in most categories and each preschool has strengths in distinct areas.

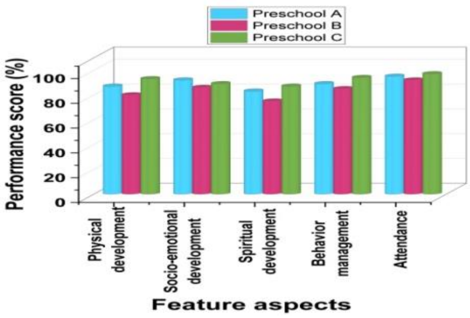

Figure 4: Comparison Of Feature Aspects

Table 4: Numerical Values of Feature Aspects

Feature aspects	Performance score (%)		
	Preschool A	Preschool B	Preschool C
Physical development	87	80	93
Socio-emotional development	92	86	89
Spiritual development	83	75	87
Behavior management	89	85	94
Attendance	95	92	97

4.4 Discussion

The system accommodates uncertainties in evaluating developmental progress. The data shows female preschoolers consistently outperform males in socio-emotional development, overall performance, behavior management, and attendance. Fuzzy Logic is a system that allows for the inclusion of qualitative and quantitative data to assess a child's holistic development. It can handle subjective data inputs like behavior management or spiritual development, and provide personalized insights. This approach enhances the accuracy and equality of evaluations, aligning them with the comprehensive nature of children's growth and learning experience in preschool settings, ensuring a widespread evaluation process.

5 Conclusion

An enhanced fuzzy logic-based system has been developed to improve assessments of preschoolers' education. This method addresses the inherent uncertainty and identities in analyzing children's progress in school. It utilized the min-max normalization for data preprocessing and PCA was implemented to extract the features. The system improves reliability in various developmental fields, including physical, socio-emotional, spiritual, behavior management and attendance. The framework recognizes each preschool's strengths and potential for expansion, providing individualized educational strategies. This adaptable and context-aware approach reduces limitations in traditional evaluating methodologies, promoting optimized academic outcomes and integrated child development. Further research could expand its application in various educational settings.

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