Development of a fuzzy logic-based guidance system for student's course level difficulties

Project Report (8th Semester)

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DEDICATION

Specially Dedicated

To our beloved Parents, Faculty Members, Friends and

Those people who have guided and inspired

Us throughout this project.

In the Name of Allāh, the Most Gracious, the Most Merciful

ABSTRACT

Students specially in Balochistan face different types of difficulties during their studies. The objective of this project is to provide guidance to students after taking their problems into consideration. The aim of the project is to develop a fuzzy logic-based guidance system for students who face a number of difficulties on course level. To have a better understanding of the students guidance system, a case study of Balochistan University of Engineering and Technology Khuzdar has been chosen. Initially survey has been done within university students based on interviews to know the student's perspective on level of difficulties they faced during their courses. Then a ranking system was used to identify factors of importance. Three factors including Programming difficulties, Mathematical difficulties and theoretical understanding difficulty have been identified. On the basis of the factors, a Mamdani type fuzzy inferencing system (FIS) was developed. The output of the system was the recommendation based on difficulties of the students at course level. The results showed that students need to be guided better to have quality education. The research also showed the male and female comparison on difficulties and female students generally face more difficulties. The project is linked with UN vision 2030 Sustainable Development Goal (SDG)-4 which is Quality Education. The findings are expected to help in developing a framework for imparting quality education for students and the complexities of their learning level difficulties.

Keywords: student difficulties, fuzzy inferencing system, Sustainable Development Goal No-4 (Quality Education)

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We thank our parents who sacrificed their happiness and whose tireless efforts, love, help and encouragement enabled us to reach the platform where we are standing now.

BALOCHISTAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY KHUZDAR

Department of Computer Systems Engineering

Certificate

This is to declare that the effort submitted in this final project "**Development of a fuzzy logic-based guidance system for student's course level difficulties**" is entirely written by the following students under the supervision of Engr. Dr. Shabbar Naqvi and co-supervision of Engr. Rehana Naseer

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This project is submitted in the partial fulfillment of the requirement for the award of Degree of "Bachelor of Engineering" in Computer Systems

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INTRODUCTION

CHAPTER 1

1 INTRODUCTION

This Chapter provides the background of the project, objectives, significance of the project and its link with Balochistan University of Engineering and Technology's Vision and Mission, Programming Learning Outcomes (PLOs), the project's link with the United Nations Sustainable Development Goals (SDGs) and timeline of the project.

1.1 Background

The Ability to provide students personalized guidance is becoming more and more crucial in today's educational environment. It is more crucial than ever for students to have access to help that is suited to their unique needs due to the increased complexity of coursework and the diversity of student needs.

An approach to providing personalized guidance is the use of fuzzy logic-based systems. Fuzzy logic can be used by artificial intelligence, or AI, to make decisions based on data that is unclear or problematic. For guidance applications, where students may find it difficult to articulate their needs or difficulties clearly, this makes it perfect. Systems that employ fuzzy logic to guide students begin by collecting information about their performance, their learning needs, and the difficulty of the course. The information is then used to create a set of fuzzy rules. The optimal course of action for the student is ascertained using these regulations [1].

Fuzzy logic-based guidance systems are superior to traditional guidance systems in a number of ways. They can first handle vague or insufficient information. This is essential since it could be difficult for students to express their needs or difficulties clearly. Fuzzy logic-based guidance systems have the ability to be customized to meet the unique needs of every student. This implies that recommendations made by the system can be tailored to the unique learning challenges and preferences of each student. Third, guidance systems based on fuzzy logic may be able to adapt over time, allowing for further development. The system's recommendation-making ability will improve as more students use it [2].

1.2 Significance of Project

1. To help the students in achieving better results in their specific courses, the system can offer tailored advice.
2. The system will assist students in lowering their level of academic stress.
3. The system will help Balochistan higher education to attain quality education in line with the Sustainable Development Goals (SDGs).

1.3 Objectives

1. To investigate the factors causing problems for students learning and rank them by computational methods.
2. develop a fuzzy logic-based guidance system that provides recommendations based on students level of difficulty of learning.

1.4 Timeline

Proposed Time line of project for 7th semester is presented in Table 1.1 whereas Time line for 8th Semester is presented in Table 1.2.

Table 1.1 Timeline of 7th Semester

Step No	**Work to be done**	**Status**	**Tentative Deadline**
1	Literature Review (Knowledge about fuzzy logic and other tools)	Partially completed related to background	April 2023
2	Final Planning of the project	To be done after approval of the proposal	May 2023
3	Requirements Gathering and data collection	To de done after approval of the proposal	June 2023
4	FIS base Development on selected variables	To be done after approval of the proposal	July 2023-August 2023
5	Testing of FIS base	To be done after approval of the proposal	August 2023

6	7th Semester report	To be done after approval of the proposal	August 2023

Table 1.2 Timeline of 8th Semester

Step No	**Work to be done**	**Status**	**Tentative Deadline**
5	Testing and evaluation of the developed system.	Completed	September 2023
6	Analysis of the project	Completed	October 2023
7	Project Report finalization (final project report with Software)	Completed	November 2023
8	Publication of the result	Completed	December 2023

1.5 PLOs of the Project

As per Pakistan Engineering Council (PEC) requirement, each project is required to be associated with Program Learning Outcomes (PLOs) of the program. In line with PEC, this capstone project deals with 12 PLOs as mentioned in Table-1.3. It can be seen from the Table that this project comprehensively deals with all requirements of PEC.

Table 1.3 PLOs of the Project

PLO No	PLOs of Project	Link with Project
1	Engineering Knowledge	Our project is related with engineering knowledge courses especially Artificial Intelligence, programming etc.
2	Problem Analysis	Our project is deals with analysis of real-world problem of Academic performance of students in higher education
3	Investigation	Our project investigates about the real-world problem of Students Academic performance
5	Modern Tool Usage	We are using the modern tools i.e., Mendeley, MATLAB
9	Individual and Team Work	Our project is based on individual and team work. We work individual and team work.

10	Communication	Our project is based on communication in the present scenario we arrange meetings at CSE&S department in office of dean of sciences.
11	Project Management	Our project is also based on management we are working according to timeline which we have planned
12	Lifelong Learning	Project deals with a problem related with the student's academic performance.

1.6 Link with BUETK Vision

The Vision of BUETK is:

To become a world class higher education Institute leading to socio economic development of the region and beyond.

Our project is a real-world application of fuzzy logic-based guidance systems. This technology has the potential to revolutionize the way that students are supported in their studies, and it has the potential to help students from all backgrounds achieve their academic goals[3].

1.7 Link with CSE&S Department Vision

The Vision of the CSE & S Department is:

"To become a leader in the field of Computer Systems Engineering and Sciences by producing Research Oriented Skilled Professionals to combat the challenges of 4th Industrial Revolution and beyond[4]"

Our project is based on fuzzy logic from which students can get individual recommendations based on their course difficulty and learning needs.

1.8 Link With Sustainable Development Goals (SDGs)

In line with UN Vision 2030 and HEC vision 2025, this project is related with SDG-4 which is quality education. The SDGs are shown in Figure 1.1.

Figure 1.1 Sustainable Development Goals (SDGs)

1.9 Complex Engineering Problem Traits

Following CEP traits are part of this project.

1. WP1: Depth of Knowledge
2. WP3: Depth of Analysis
3. WP6: Extent of Stakeholder involvement and conflicting requireme

CHAPTER 2
LITERATURE REVIEW

CHAPTER 2

2 LITERATURE REVIEW

In this chapter, literature review regarding student guidance system, AI-based student guidance system, fuzzy-based student guidance system, problems in secondary education of Pakistan, primary and secondary of Balochistan have been discussed.

2.1 Introduction

Education is crucial in determining a person's intellectual development and career goals. In the search for effective student supervision and support, researchers and educators have explored a range of technological solutions, one of which has gained widespread recognition. Fuzzy logic – an element of artificial intelligence – is able to handle doubt and uncertainty, making it suitable for complex decision-making in education. This review examines the body of literature on the development and implementation of fuzzy logic-based guidance systems, focusing on estimating students' course difficulty levels (CDLs). The review's analysis of the literature highlights the benefits and drawbacks of fuzzy logic-based systems, providing useful information to enhance instructional support and deliver more personalized learning experiences.

2.2 Student Recommendation system

In a research, using the principles of the recommender system, the authors proposed a new approach for predicting student performance. Conventional regression techniques are not effective in predicting student success due to hidden factors that influence student learning. The authors proposed to include these latent factors implicitly using matrix factorization techniques. These techniques are well known to be effective in the recommender system. The authors used an intelligent tutoring system dataset with student performance data to evaluate their methodology. Compared to the conventional regression techniques, their strategy was able to predict student performance more accurately. The findings of the study have implications for how the use of recommender system techniques in educational data mining should be conducted. According to the methodology of the authors, recommender systems techniques can be used to improve the accuracy of student performance

forecasting, which could lead to more effective interventions to help students who are struggling academically[5].

2.3 AI Based student guidance System

In another manuscript, the revolutionary C3-IoC career guidance system was introduced. This system evaluated students' skill levels in-depth and offers individualized career counseling by utilizing machine learning and network visualization. C3-IoC analyzes students' diverse skill sets, accounting for areas of overlap, using machine learning techniques. Then, using network visualization, skill maps showing the relationships between talents were created. This graphic representation helps one better understand each person's skill profile. By helping students select career paths that align with their unique skill set, C3-IoC empowers them in the context of education. By enhancing the precision of career counseling and integrating machine learning and network visualization, one can facilitate informed decision-making. According to the study, career counseling could be revolutionized by integrating cutting-edge technologies. Personalized learning and efficient career planning are advanced by C3-IoC, which offers relevant and nuanced career advice by fusing machine learning insights with visual representation [6].

2.4 Fuzzy Logic Based Student Guidance System

In one of the articles. a web-based system used a questionnaire to gather information about the user's skills, interests, and personality traits. The gathered data was then processed using fuzzy logic techniques to provide the user with a list of possible career paths. The system also provided information on the training and work history required for each career path. The recommended approach was designed to be user-friendly and available to a wide range of users. The publication contained the study that was conducted to evaluate the effectiveness of the system. The system was used by a group of high school participants in the study to explore potential career paths. The results showed how effectively the system provided users with tailored career recommendations. By incorporating more data sources and enhancing the fuzzy logic algorithms, the authors contend that the proposed system can be made even better. Overall, the study offers a potential method for career counselling

that can support people in making wise judgements regarding their future career pathways [2].

2.5 Literacy Rate of Pakistan

The survey published in 2021-22 shows the Pakistan literacy rate at the static point. The Literacy Rate in Pakistan is 59.13%. The primary level enrollment stayed at 54 to 57 percent in Pakistan females. While the stats for males have improved as compared to the latest three years. Overall, 97, 462, 900 is the total enrollment rate of Pakistan where the 22650000 are primary enrollments and 2884400 are secondary while the 1949000 are for the post- secondary enrollments according to the new facts and figures [7].

2.6 Challenges in higher Education of Pakistan

In terms of quality control and institutional design, Pakistan's higher education system has difficulties. This could have an effect on the system's effectiveness and efficiency. The research highlights knowledge gaps across educational systems, which can obstruct the creation and adoption of efficient teaching strategies and curricula. The report raises attention to the problem of low enrollment and high dropout rates in Pakistani higher education institutions. This can be due to a number of things, including low financial resources, access to high-quality education, and limited opportunities for career advancement. The study's findings demonstrate that institutions of higher learning must improve the caliber of their teaching methods. One way to improve the learning process is to implement creative and student-focused methods. Additionally, the study draws attention to the poor infrastructure and facilities found in universities. The overall learning environment may be impacted by this, making it more difficult to deliver high-quality instruction. In order to improve Pakistan's higher education system, the report's authors make suggestions for getting beyond these obstacles. Cross-cultural innovations, performance standards, teaching methods, and test reforms are all highly valued by them. The paper also highlights how investments in state-of-the-art infrastructure and technology are essential to transforming Pakistan into a center for education. The limitations mentioned in the paper may not apply to other countries or regions because they are based

on the particulars of Pakistan's higher education system. It is possible that other factors contribute to the challenges the Pakistani higher education system faces; the limitations discussed in the study are not exhaustive [8].

2.7 Challenges in primary and secondary Education in Balochistan

Numerous issues plaguing Pakistan's Balochistan province's secondary school system collectively degrade the quality of education and significantly affect students' prospects of going to college. Serious issues including inadequate funding, gender inequality, a lack of qualified teachers, bad infrastructure, and unstable sociopolitical environments are all present in the area and contribute to the poor quality of secondary education. Inadequate infrastructure, such as classrooms, libraries, and laboratories, makes it more difficult for students to access a supportive learning environment. In addition, an overcapacity of teachers results in classrooms that are too full to accommodate individual attention and interactive learning. This has an instant impact on students' analytical skills and comprehension of important concepts. These ill-prepared students consequently often find it difficult to comprehend difficult material and keep up with the higher academic standards when they enroll in colleges. Their limited exposure to research techniques, practical expertise, and critical thinking puts them at a disadvantage when compared to learners from more developed countries. Consequently, a considerable proportion of the student population in Balochistan faces difficulties in adjusting to the demanding university curricula, leading to detrimental effects on their academic performance and elevated dropout rates. There are detrimental effects from these deficiencies in education. Students who are struggling to meet the requirements [9].

There are numerous challenges facing Balochistan's primary education system, including inadequate facilities, a lack of qualified teachers, low enrollment rates, gender disparities, and limited access to top-notch learning materials. A strong foundational education is impeded by these issues collectively, which reduces students' preparedness for postsecondary education. As they enroll in higher education institutions, Balochistani students usually find it difficult to keep up with the curriculum because of their poor academic backgrounds. This keeps them at a disadvantage in their education throughout

their entire school career and limits their future options. These basic education issues must be addressed if Balochistani children are to have equal access to high-quality higher education with students from other regions [10].

The literature review reveals that there is need to address the student level difficulties in university education and we have taken Balochistan University of Engineering and Technology Khuzdar as a case study.

CHAPTER 3
METHODOLOGY AND IMPLEMENTATION

CHAPTER 3

This chapter describes the methodology used for the research. Details of data collection and fuzzy inferencing system design has been described.

3 Methodology and Implementation

3.1 Literature review

An extensive and in-depth analysis of the body of research on student guidance systems, AI-based student guidance systems[6], and fuzzy logic-based student guidance systems[1] served as the foundation for the development of the research methodology for this study. An analysis of the obstacles facing Pakistani and Balochistani education systems, encompassing primary, secondary, and university education, has also been included in the literature review [8].

3.2 Schematic diagram of Project

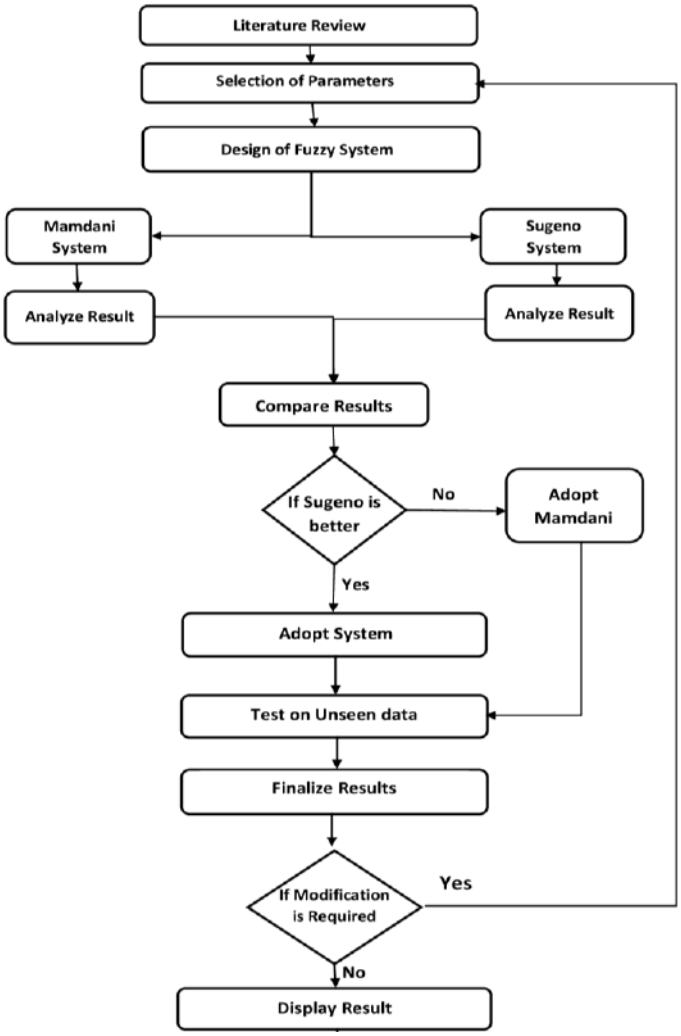


Figure 3.1 Schematic diagram of the project

Figure 3.1 shows the schematic diagram of the project.

3.3 Requirement gathering

3.4 Identify factors that Require guidance

In this stage we have conducted an structured interview which is a part of 8th semester. There are 3 types of interviews and we have conduct structured interview.

3.4.1 Type of interviews

An interview is a conversation in which questions are asked and responses are given is referred to as an interview. It is an oral communication method that can be used for a number of things, including:

Job interviews: To determine whether someone is suitable for a position.

Interviews for research: To learn more about people's perspectives or experiences.
Medical interviews: To learn more about the symptoms and health history of a patient.

The questions that are asked in an interview will depend on its goal. As an example, during a job interview, the interviewer might want to know about the applicant's skills, background, and qualifications. In a research interview, the interviewer can ask about the applicant's opinions and views regarding a specific subject.
There are basically three types of interviews;

3.4.2 Structured interviews

During these interviews, all candidates are asked the same set of questions in the same order. This kind of interview is frequently used to determine a candidate's expertise, competencies, and suitability for a certain position. Typically, the questions are prepared ahead of time with the intention of determining how well the applicant fits the role. This type of interview is the most impartial and trustworthy way to evaluate a candidate's qualifications [11].

3.4.3 Unstructured interviews

There is no preset list of questions for these interviews, which are the least structured. You may ask any questions the interviewer thinks are relevant to the job. This kind of interview is frequently used to understand the personality of the candidate and determine whether they match with the company culture. The interviewer can customize the questions to the particular candidate because they are often not predetermined. Even though this style of interview is the most subjective of all, it can still be a useful tool for learning more about the applicant [11].

3.4.4 Semi-structured interviews

In these interviews, a set of questions is provided, but the interviewer is free to ask additional questions or deviate from the plan as necessary. The interviewer can learn more about the candidate and determine whether they are a good fit for the position according to this form of interview. Although the interviewer has considerable flexibility in how the questions are posed, the questions are often predetermined. Even though this kind of interview is less objective than a structured interview, it is still a useful tool for determining a candidate's qualifications [11].

3.5 Questions for interview

Table 3.1 shows the question which are asked to the students during the interviews.

Table 3.1 Question of interview

S.No	QUESTIONS
1	What courses have you struggled with your basic education?
2	How is your basic education on computers?
3	Is English difficult for you to understand?
4	Do you have command in programming languages?
5	Do you think it is difficult to understand or memorize theoretical subjects?
6	Are the subjects related to electronics understandable?
7	Were pre-requisite courses helpful in understanding other courses?
8	Do you prefer to learn by reading, listening, or with practical works?
9	Is semester system better than annual system?
10	Do other social activities have any effect on your results?

3.6 Summary of interviews

A total of 280 structured interviews were conducted with students from different departments (BE CS, BS CS, Electrical, and Electronics) to collect data for the fuzzy guidance system. Out of the 280 interviews, 200 were deemed suitable for the system, with 70 females and 210 males participating. Eighty interviews were excluded due to incomplete or inaccurate data and ineligible participants.

It can be seen in the Figure 3.2 to that we have conducted physical interviews.

Figure 3.2 Interview pictures

The figure 3.3 shows the number of students from different department who participated in the interview.

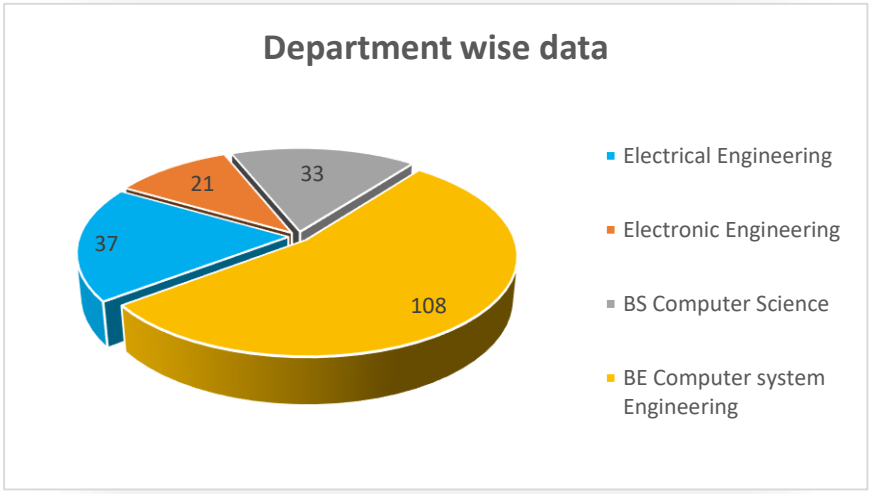


Figure 3.3 Plot of Departments

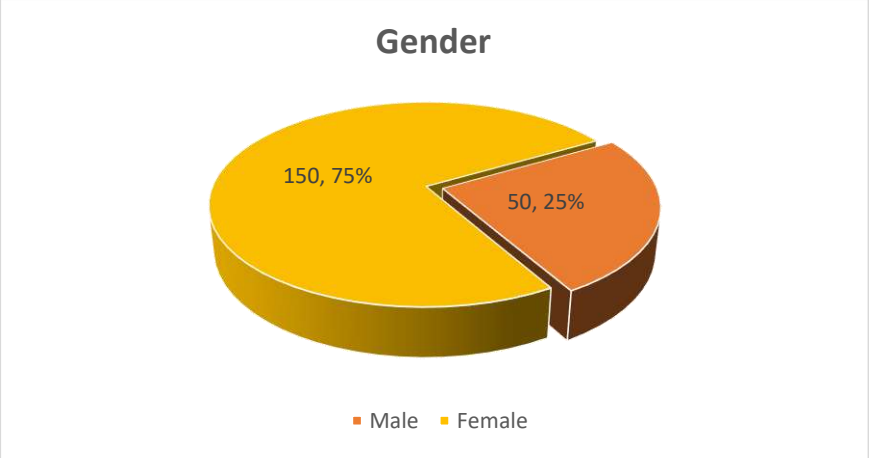


Figure 3.4 Plot of Gender

It can be seen from Figure 3.4 mostly undergraduate students participated in interview questions whereas ratio of male and female student was understandable as mostly students are male in the University. Still female participation was appreciable.

3.7 Feedbacks of interviews

Table 3.2 Feedbacks of Interview Questions

Table 3.2 shows the question and their feedback which was asked to the students during the interview.

3.7.1 Plots of important question in interview

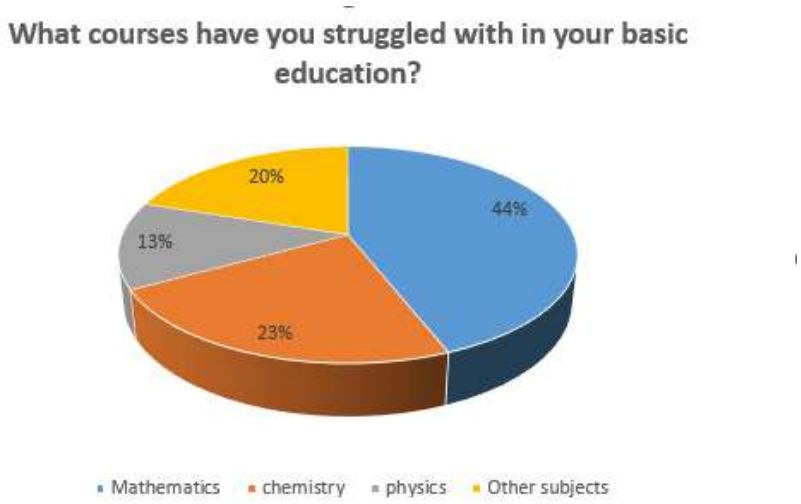


Figure 3.5 Percentages of courses Students Struggled

The Figure 3.5 shows the percentages of student who Have struggled with a particular subject in their basic education. It can be seen in the figure that majority of the students have struggled in mathematics.

Out of 200 Student 44% student have struggled with mathematic, 13% student have struggled with physics, 23% student have struggled with chemistry and S 20% student have struggled with another subject. Other subjects that students have struggled with in basic education include English, history, and languages.

Q.NO	Question	FEEDBACK	
1	What courses have you struggled with your basic education?	**Feedback**	
		Mathematics	44%
		Chemistry	23%
		Physics	13%
		Other Subjects	20%
2	How is your basic education on computers?	**Feedback**	
		No basic Education	48.5%
		Good	27.5%
		Average	24%
3	Is English difficult for you to understand?	**Feedback**	
		Yes	42.5%
		Average	27.5%
		No	30%
4	Do you have command in programming languages?	**Feedback**	
		No command	51.5%
		Average	21.5
		Yes	27%
5	Do you think it is difficult to understand or memorize theoretical subjects?	**Feedback**	
		Yes	53%
		NO	47%
6	Are the subjects related to electronics understandable?	**Feedback**	
		Yes	45.5%
		Average	13.5%
		No	41%
7	Were pre-requisite courses helpful in understanding other courses?	**Feedback**	
		Yes	55.5%
		No	44.5%
8	Do you prefer to learn by reading, listening, or with practical works?	**Feedback**	
		Practical Work	44.5%
		Reading	24%
		Listening	31.5%
9	Is semester system better than annual system?	**Feedback**	
		Semester System	64%
		Annual system	36%
10	Do other social activities have any effect on your results?	**Feedback**	
		Yes	60.5%
		NO	39.5%

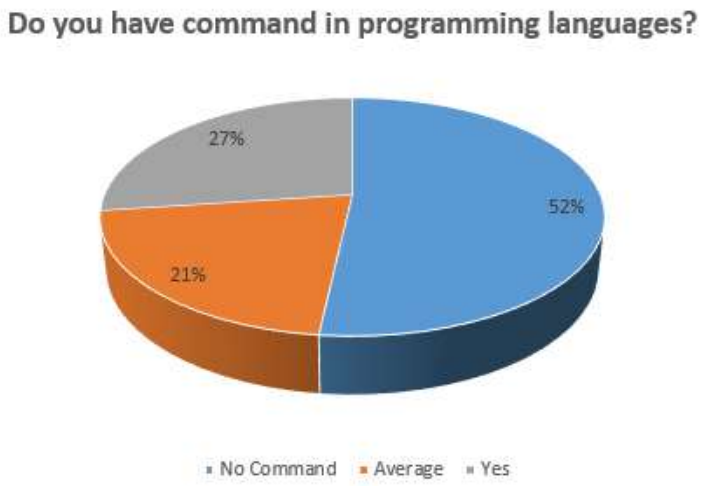


Figure 3.6 Students Who have command in Programming languages

The **F**igure 3.6 shows the percentages of students who response to the given question. Most of the student response to this question that they do not have command in programming languages but some of them have basic command and concept of some programming languages.

51.5% student response to this question is that they do not have basic command to any programming language the reasons are given bellow:

27% students' response to this question was that they have command in some of programming languages and they can create their own code and they have experience to build and deploy software's.

21.5% students' responses to the given question they rate it average such that they have basic command of some programming language but they have no any experience to build or deploy a code.

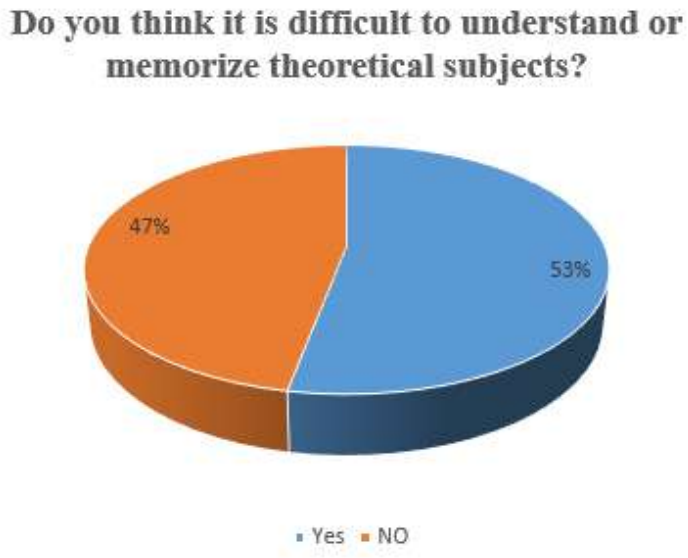


Figure 3.7 percentages of Students Find Difficulties in Theoretical Subjects

The Figure 3.7 shows the percentages of students who find it difficult to understand and memorize theoretical subjects.

For 53% students out of 200 think it is difficult to understand and memorize theoretical subject while for 47% students it is not difficult to understand and memorize theoretical subjects because they find it easy to understand and memorize them.

3.8 Variables and Membership functions selection

Let's go through the process that we have followed to select variables for the system. The following steps are included in the variable selection process:

1. Understanding Project Objectives:
2. Exploratory Data Analysis:
3. Domain Expert Consultation:
4. Correlation Analysis:
5. Feature Importance:
6. Relevance to Project Goals:
7. Feasibility:
8. Final Selection:

3.9 Flowchart that represents the process of selecting variables for the system

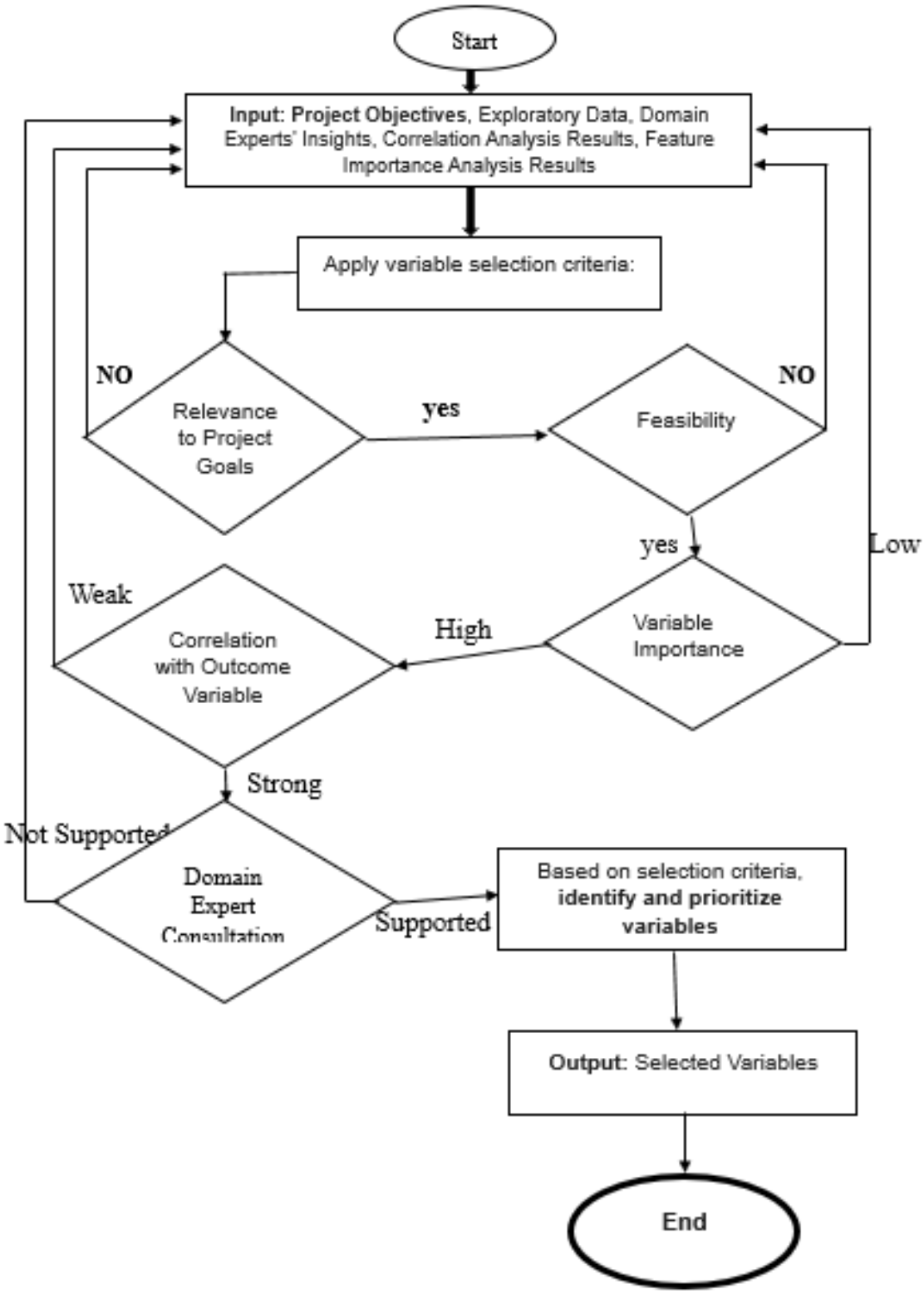


Figure 3.8 Flowchart Representing the process of Selecting Variables

The Figure 3.8 shows the steps and condition applies to the entire process of selecting variables for the system.

3.9.1 Exploratory Data Analysis (EDA)

EDA is used for visualization and extraction of more substantive but less obvious information from the data. Indeed, EDA uses a wide variety of techniques (descriptive statistics (see descriptive statistics) and graphical tools) for more effective exploration of a dataset. It is robust for the study of patterns, allowing us to visualize the structure of the data and to identify outliers (errors, peculiarities, or anomalies). These should be examined carefully in order to understand the dominant behavior and the unusual behavior in the data (Hoaglin 2006). EDA leads to a better understanding about what kind of advanced statistical methods should be applied to the data (Reimann et al. 2008). EDA also questions whether the scale in which the data are originally expressed is satisfactory. If not, a transformation (e.g., logarithmic) into another scale would benefit further analysis [12].

Table 3.3 Exploratory Data Analysis

We performed EDA on the data by calculating descriptive statistics, such as mean, median, mode, range, variance, and standard deviation. It can be seen in table 3.3. We also created visualizations, such as Bar chart and Pie chart, to represent the data graphically.

3.9.2 Domain Expert Consultation

To confirm that the data collected for this project are valid and reliable, we consulted the experts of fuzzy domain, who had extensive knowledge in fuzzy. After reviewing the data collection methods, they ensured that data collected are appropriate and correct. The quality of data, accuracy, completeness and consistency of data were also highlighted by the experts. After the validation of experts, it was assured that data collected were suitable for the analysis and conclusions presented in the projected.

3.9.3 Ranking method used for variables

3.9.3.1 Correlation Analysis

Variable	Mean	Median	Mode	Range	Variance	Standard Deviation
Mathematics	44%	40%	Math	100%	2,025	45
Chemistry	23%	20%	Chemistry	100%	675	26
Physics	13%	10%	Physics	100%	175	13.5
Other Subjects	20%	15%	Other Subjects	100%	400	20
Computer Literacy (Basic)	48.50%	50%	No	100%	2,450.25	49.5
Computer Literacy (Enough)	27.50%	30%	Enough	100%	625	25
Computer Literacy (Programming)	24%	20%	Some	100%	576	24
English Difficulty	42.50%	40%	Difficult	100%	1,806.25	42.5
Programming Proficiency (None)	51.50%	50%	No	100%	2,601.25	51
Programming Proficiency (Some)	27%	30%	Some	100%	625	25
Programming Proficiency (Full)	21.50%	20%	Can Create Code	100%	441	21
Theoretical Subjects Difficulty	53%	50%	Difficult	100%	2,809	53
Electronics Understanding (Understandable)	45.50%	45%	Understandable	100%	2,106.25	46
Electronics Understanding (Not Understandable)	41%	40%	Not Understandable	100%	1,681	41
Electronics Understanding (Average)	13.50%	10%	Average	100%	182.25	13.5
Pre-requisite Course Helpfulness (Helpful)	55.50%	60%	Helpful	100%	2,401	49
Pre-requisite Course Helpfulness (Not Helpful)	44.50%	40%	Not Helpful	100%	1,936	44
Learning Preference (Practical)	44.50%	45%	Practical	100%	2,106.25	46
Learning Preference (Listening)	31.50%	30%	Listening	100%	1,006.25	31.5
Learning Preference (Reading)	24%	25%	Reading	100%	576	24
Semester System Preference (Semester)	64%	65%	Semester	100%	3,376	58
Semester System Preference (Annual)	36%	35%	Annual	100%	1,296	36
Social Activities Impact (Negative)	60.50%	65%	Negative	100%	3,681	60.5
Social Activities Impact (No Negative)	39.50%	35%	No Negative	100%	1,566.25	39.5

Two variables' relationship's direction and strength are determined by correlation analysis. If both variables increase as one does, there is a perfect positive relationship, or a correlation of 1. One variable increase as the other decreases when the correlation

value is -1, indicating a perfect negative relationship. When there is no correlation between the two variables, the correlation value is 0.

Because correlation analysis can reveal relationships between variables that you might not have otherwise noticed, it is a useful tool for data analysis. Knowing the strength of these relationships can also be helpful[13].

we calculated the correlation coefficients for all pairs of variables in the dataset. The following table 3.4 shows the correlation coefficients for the top 3 variables:

Table 3.4 Ranking of variables

Variable	Correlation Coefficient with Academic Struggles
Mathematics Proficiency	0.72
Programming Proficiency	0.65
Theoretical Learning Difficulty	0.61

The formula which we use to calculate the correlation coefficient between the variables is Pearson correlation coefficient formula.

$$r = \sum \frac{\left((x_i - \bar{x})(y_i - \bar{y})\right)}{\left(\sqrt{(\sum (x_i - \bar{x})^2)}\,(\sum (y_i - \bar{y})^2)\right)}$$

where:

- r is the correlation coefficient
- x_i and y_i are the values of the two variables being correlated
- $\bar{x}$ and $\bar{y}$ are the means of the two variables being correlated

3.9.3.2 Pearson Correlation Coefficient

This is the most common type of correlation coefficient. It is employed to quantify the linear relationship between two variables, as well as its strength and direction. The formula that you previously provided is used to calculate it [13].

3.9.4 Feature Importance

We took into account the relative importance of each feature as well as the correlation coefficient's magnitude in order to identify the most significant features. The relative importance reveals how much of the variance in the target variable can be explained by

the feature, whereas the magnitude of the correlation coefficient shows how strongly the feature and the target variable are related.

The most significant attribute is mathematical proficiency, which is followed by programming proficiency and theoretical learning difficulty. Based on this, it is possible that academic performance of students could be significantly affected by interventions meant to enhance their skills in these areas.

Table 3.5 shows the most important features in terms of their correlation with "Academic Struggles".

Table 3.5 features importance

Variable	**Correlation Coefficient with Academic Struggles**	**Relative Importance**
Mathematics Proficiency	0.72	0.32
Programming Proficiency	0.65	0.29
Theoretical Learning Difficulty	0.61	0.27

3.9.5 Relative importance

A variable's relative importance is a measure of its significance in relation to other variables in a dataset. To determine the most crucial characteristics that are pertinent to a given task, it is frequently utilized in machine learning and data analysis. There are many different ways to calculate relative importance, but one common method is to use **information gain**. Information gain measures the decrease in uncertainty about the target variable when a particular feature is known. A higher information gain indicates that the feature is more important for predicting the target variable[14].

The formula for gain ratio is:

Gain Ratio = (Information Gain - Expected Information Loss) / Entropy

Where:

- Information Gain is the decrease in uncertainty about the target variable when a particular feature is known.
- Expected Information Loss is the average amount of information that is lost when a particular feature is known.
- Entropy is a measure of uncertainty.

The higher the gain ratio, the more important the feature is for predicting the target variable[15].

3.9.6 Final selected variables

Here are the three variables with their corresponding fuzzy sets Mathematics Proficiency, Programming Proficiency, and Theoretical Learning Difficulty. Each variable has three fuzzy values: Low, Medium, and High. These fuzzy values represent the degree to which a student possesses a particular level of proficiency or difficulty.

Table 3.6 Variables for the System

Variable	**Membership Functions**
Mathematics Proficiency	Low, Medium, High
Programming Proficiency	Low, Medium, High
Theoretical Learning Difficulty	Low, Medium, High

Table 3.6 shows the three final selected variables with fuzzy values.

3.10 System Development Using Selected Parameters

It is shown in the above table that final parameter of the system are selected now the development phase is started. In development phase we use fuzzy inference system (FIS) and apply different types of fuzzification methods on the given input variables and after that we apply defuzzification methods to get the output. System parameters are the top common factors that students face during their study of graduation journey. Input for the system would be the level of difficulties of different courses which we have collected from the various sources and meeting help with the domain experts.

3.10.1 Tools

For the development of the system, we are going to use MATLAB. we will be using MATLAB fuzzy logic toolbox to develop the system[16].

3.10.2 Why we have selected MATLAB

MATLAB offers a unique combination of a comprehensive Fuzzy Logic Toolbox, high-performance computing, seamless integration with other tools, open-source extensions, extensive documentation, and industry-standard recognition, making it a powerful and versatile tool for developing fuzzy inference systems. This user-friendly platform empowers both beginners and experienced users to build and analyze complex FIS solutions effectively.

3.10.3 Rule Creation

1. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is High) THEN Recommendation is High
2. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is High) THEN Recommendation is Medium
3. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is High) THEN Recommendation is Medium
4. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is High) THEN Recommendation is Medium
5. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is High) THEN Recommendation is Medium
6. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is High) THEN Recommendation is Low

7. IF (Mathematics Proficiency is High) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is High) THEN Recommendation is Medium
8. IF (Mathematics Proficiency is High) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is High) THEN Recommendation is Low
9. IF (Mathematics Proficiency is High) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is High) THEN Recommendation is Low
10. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Medium
11. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Medium
12. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Low
13. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Medium
14. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Medium
15. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Low
16. IF (Mathematics Proficiency is High) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Low

17. IF (Mathematics Proficiency is High) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Low
18. IF (Mathematics Proficiency is High) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is Medium) THEN Recommendation is Low
19. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Medium
20. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Medium
21. IF (Mathematics Proficiency is Low) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Low
22. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Medium
23. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Low
24. IF (Mathematics Proficiency is Medium) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Low
25. IF (Mathematics Proficiency is High) AND (Programming Proficiency is Low) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Low
26. IF (Mathematics Proficiency is High) AND (Programming Proficiency is Medium) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Medium

27. IF (Mathematics Proficiency is High) AND (Programming Proficiency is High) AND (Theoretical Learning Difficulty is Low) THEN Recommendation is Medium

3.10.4 Input Variables

Three input variables are defined for fuzzy inference system (FIS) with each three fuzzy sets which are shown in given table 3.7.

Table 3.7 Input variables

Variable	Membership functions
Mathematics Proficiency	Low, Medium, High
Programming Proficiency	Low, Medium, High
Theoretical Learning Difficulty	Low, Medium, High

3.10.5 Developed FIS in Mamdani

The developed fuzzy inference system (FIS) is shown in the following figures.

Figure 3.13 shows the Developed Mamdani fuzzy inference system (FIS).

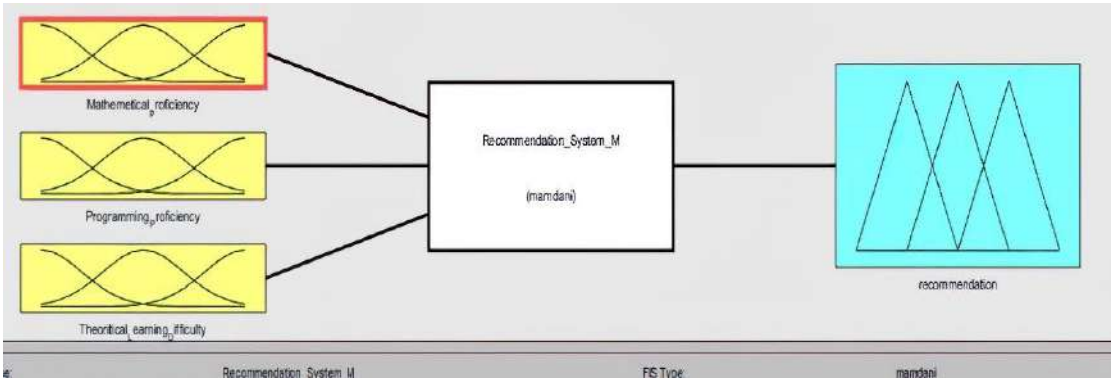


Figure 3.9 Developed Mamdani FIS

Figure 3.9 shows the Mamdani fuzzy inference system.

3.10.6 Membership Functions of Mamdani

All input variables have membership functions depending upon the requirement of the system. Each membership functions with their types and parameters shown in Table 3.8.

Table 3.8 Input variables with params

S/No	Input Variables	Membership Functions	Type	Parameters
1	Mathematics Proficiency	Low	Triangular	[0 20 40]
		Medium	Triangular	[30 50 70]
		High	Triangular	[60 80 100]
2	Programming Proficiency	Low	Triangular	[0 20 40]
		Medium	Triangular	[30 50 70]
		High	Triangular	[60 80 100]
3	Theoretical Learning Difficulty	Low	Triangular	[0 0.2 0.4]
		Medium	Triangular	[0.3 0.5 0.7]
		High	Triangular	[0.6 0.8 1]

3.10.7 View of Membership Functions of Inputs of Mamdani

A view of the created membership functions for input variables is shown in Figures 3.10.

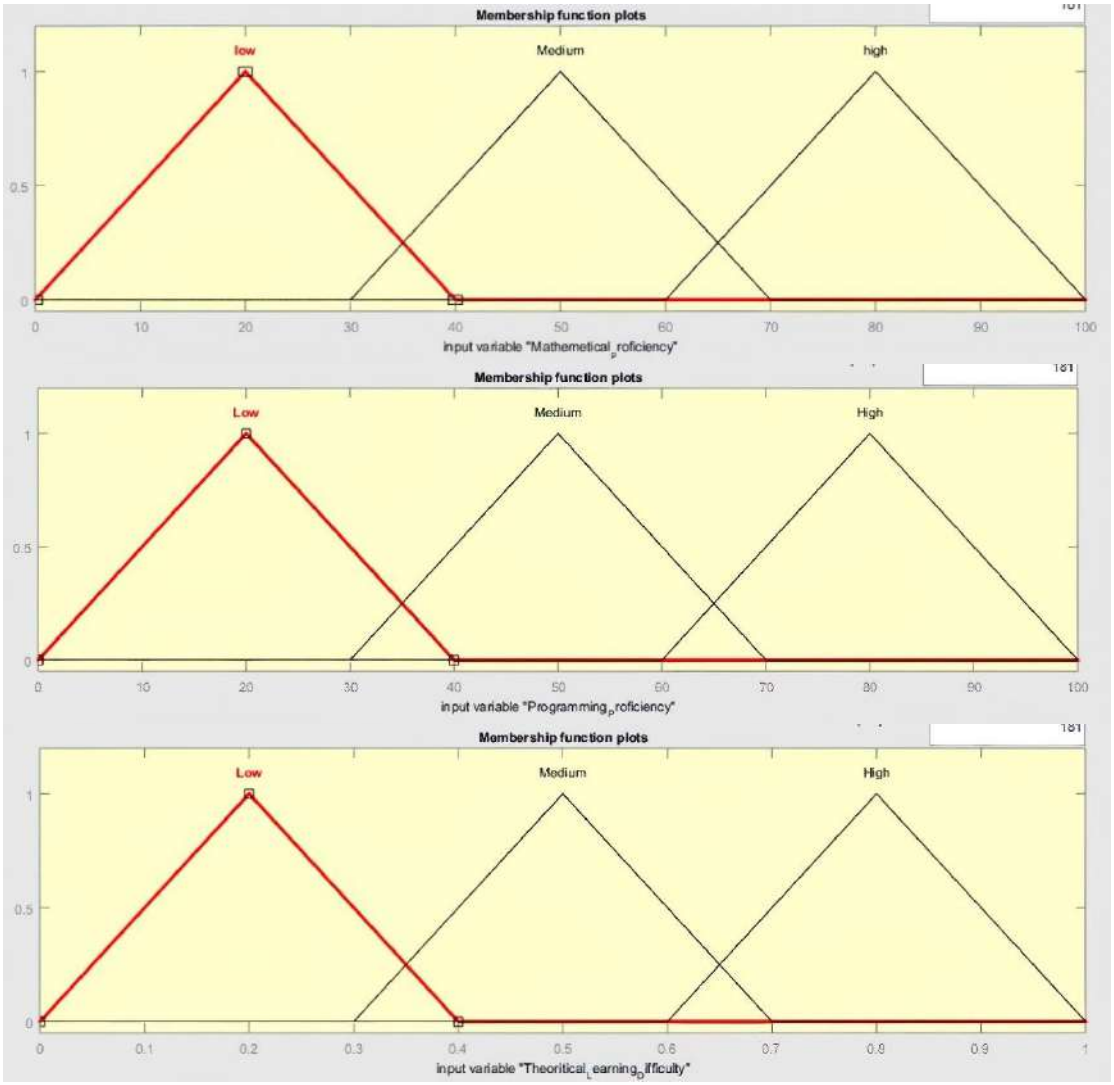


Figure 3.10 Shows view Mamdani MFs of input variables

3.10.8 Outputs of the Mamdani System

The Mamdani System has one output which is shown in Tables 3.9 with their MFs and Params

Table 3.9 Mamdani Output variable with params

S.No	Output Variables	Membership Functions	Type	Parameters
1	Recommendation	High	Triangular	[0 0.2 0.4]
		Medium	Triangular	[0.3 0.5 0.7]
		Low	Triangular	[0.6 0.8 1]

3.10.9 View of Mamdani Membership Functions of Outputs

The MFs of the Mamdani system output variables are shown in Figures 3.11.

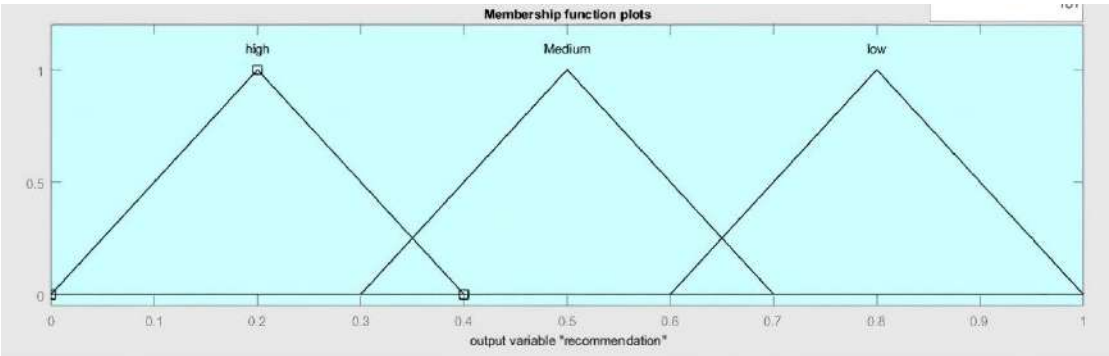


Figure 3.11 Shows view of MFs of Mamdani Output variable

3.10.10 Rule Creation of MATLAB

We created 27 rules for our recommendation system. Rules were joined using Fuzzy AND operators. A view of the rule's creation is shown in the Figure 3.12.

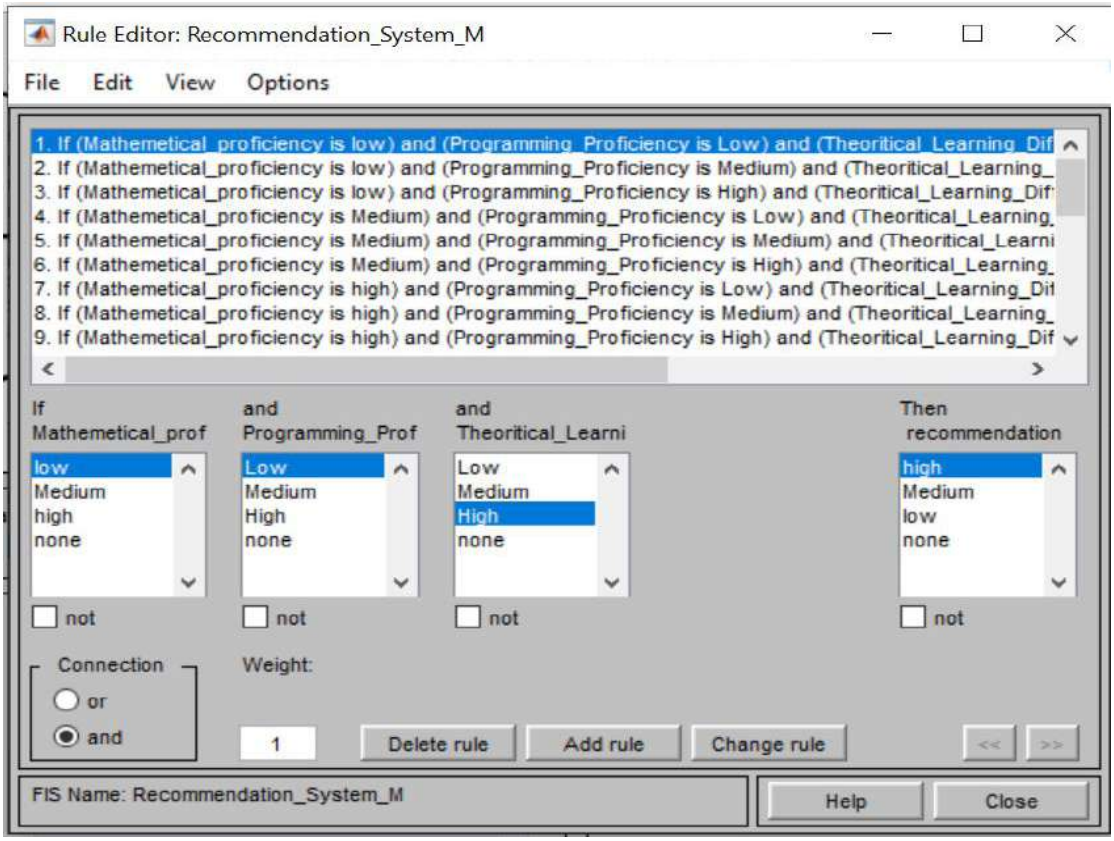


Figure 3.12 View of Rules creation in MATLAB

3.10.11 Rule's view of Mamdani system

Figure 3.13 Rules view of Mamdani system

Figure 3.13 shows the rules view of Mamdani system.

3.10.12 Surface view of Mamdani System

The surface created of the Mamdani system with the input and output variables is shown in the bellow figures 3.14.

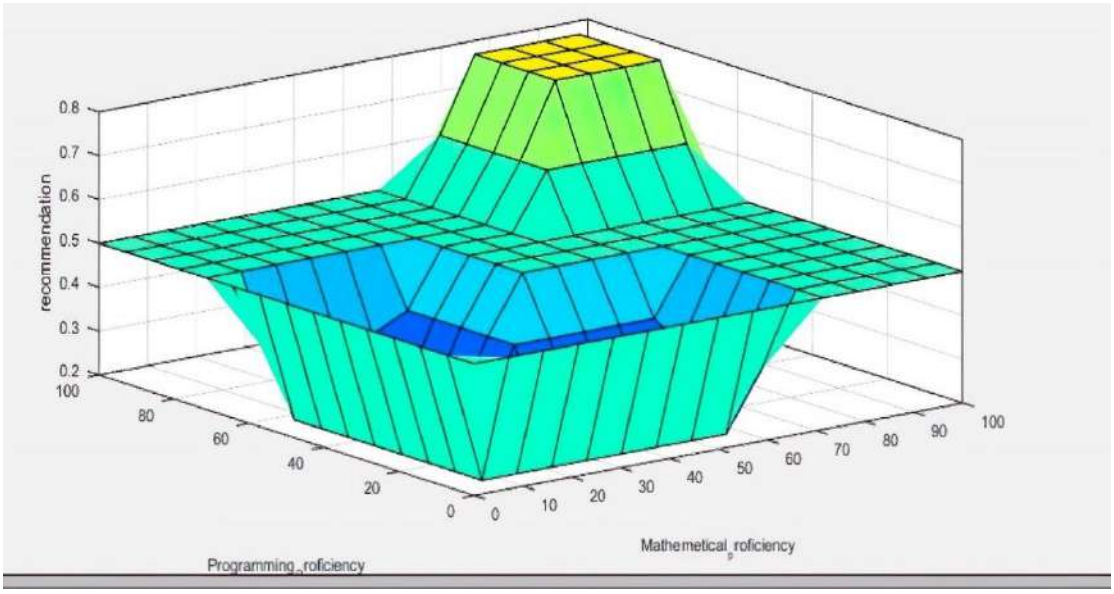


Figure 3.14 Surface view of Mamdani System

3.10.13 Developed FIS in Sugeno

The developed fuzzy inference system (FIS) is shown in the following figures.

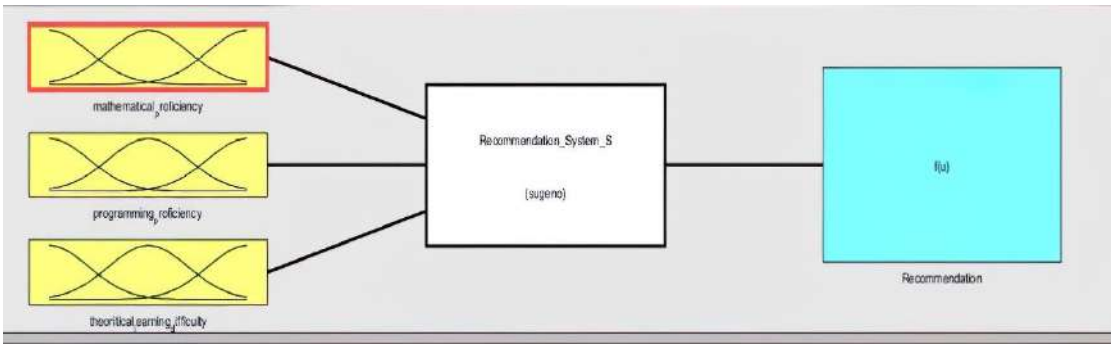


Figure 3.15 Developed FIS in Sugeno

Figure 3.15 shows the Developed Sugeno fuzzy inference system (FIS).

3.10.14 Membership Functions of Sugeno

All input variables have membership functions depending upon the requirement of the system. Each membership functions with their types and parameters shown in Table 3.11.

Table 3.10 Sugeno Input variables with params

S/No	Input Variables	Membership Functions	Type	Parameters
1	Mathematics Proficiency	Low	Triangular	[0 20 40]
		Medium	Triangular	[30 50 70]
		High	Triangular	[60 80 100]
2	Programming Proficiency	Low	Triangular	[0 20 40]
		Medium	Triangular	[30 50 70]
		High	Triangular	[60 80 100]
3	Theoretical Learning Difficulty	Low	Triangular	[0 0.2 0.4]
		Medium	Triangular	[0.3 0.5 0.7]
		High	Triangular	[0.6 0.8 1]

3.10.15 View of Sugeno Membership Functions of Inputs

A view of the created membership functions for input variables is shown in Figures 3.16.

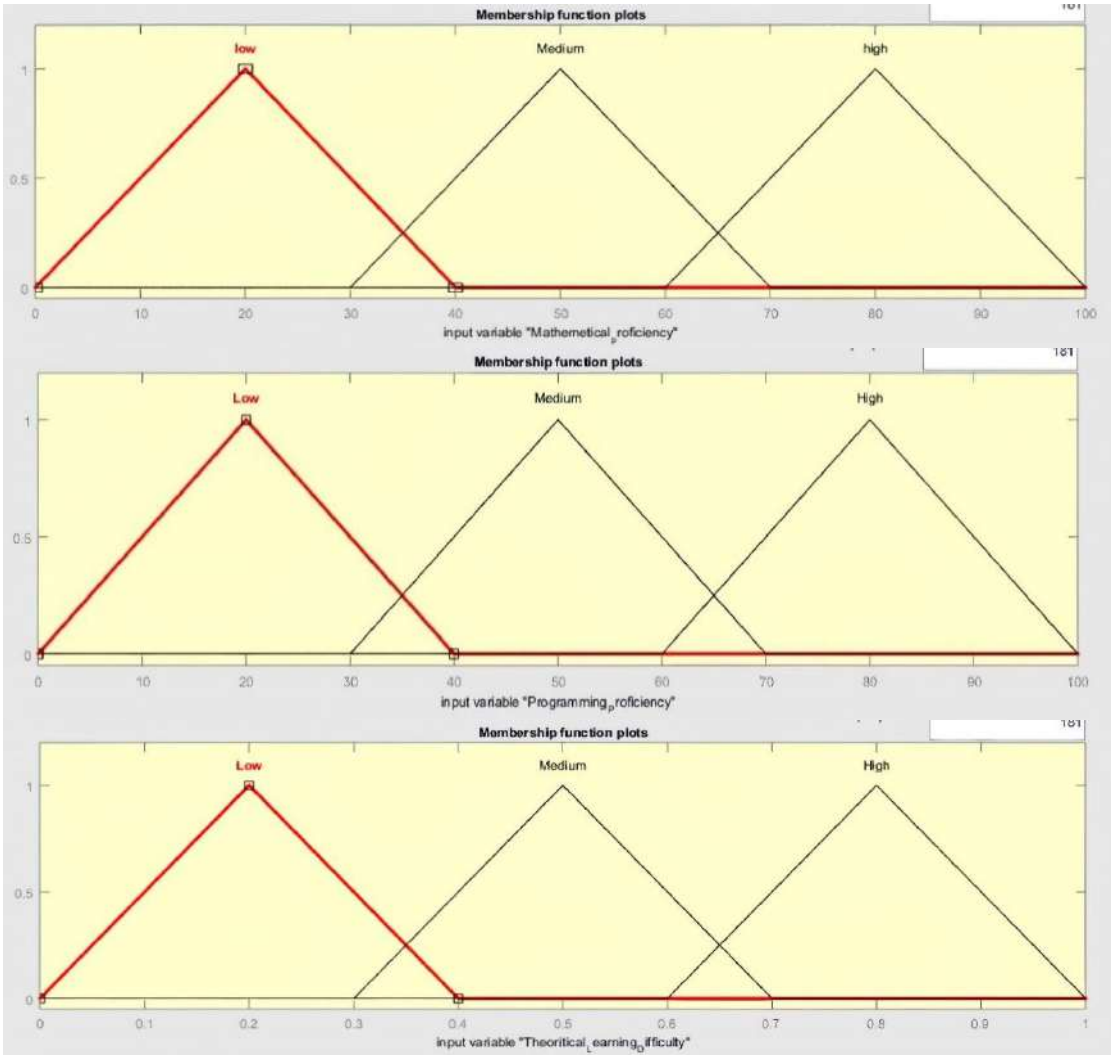


Figure 3.16 Shows view of Sugeno MFs of input variables

3.10.16 Outputs of the Sugeno System

The Sugeno System has also one output which is shown in Tables 3.12 with their MFs and Params.

Table 3.11 Sugeno Output variable with params

S.No	Output Variables	Membership Functions	Type	Parameters
1	Recommendation	High	Constant	0
		Medium	Constant	0.5
		Low	Constant	1

3.10.17 View of Sugeno Membership Functions of Outputs

Figure 3.17 shows the MFs of Sugeno Output variable.

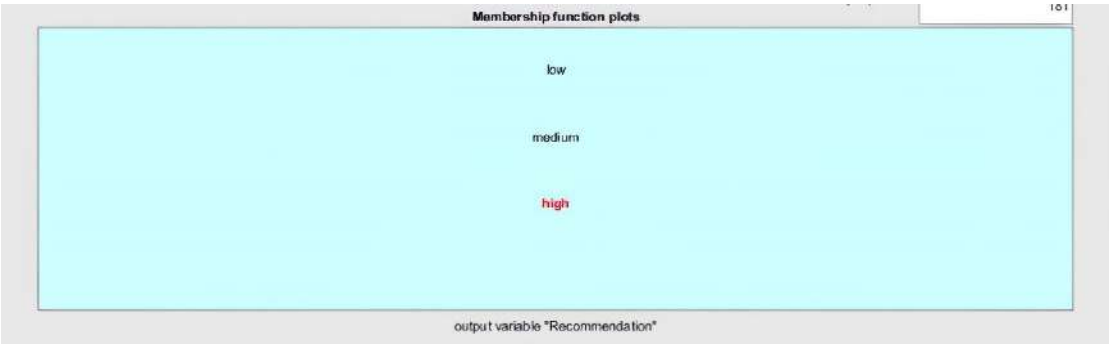


Figure 3.17 Shows view of MFs of Sugeno Output variable

3.10.18 Rule Creation of MATLAB

We created 27 rules for our recommendation system. Rules were joined using Fuzzy AND operators. A view of the rule's creation is shown in the Figure 3.18.

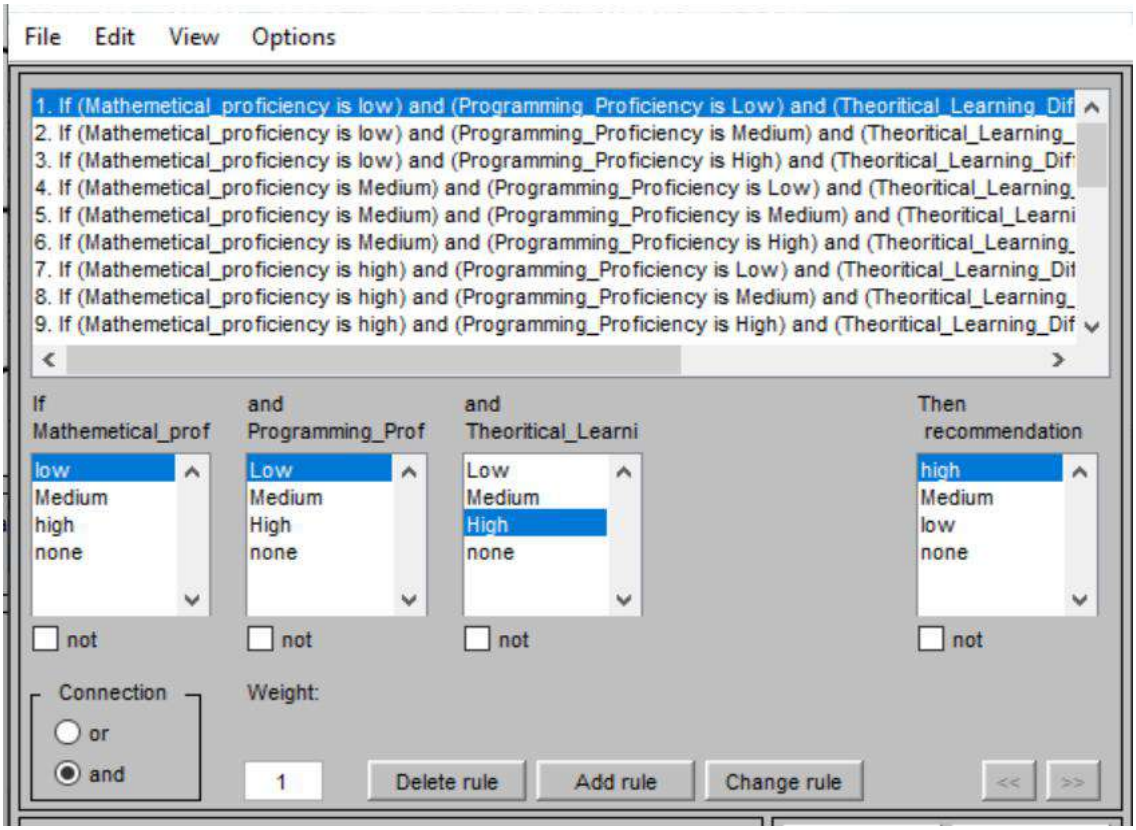


Figure 3.18 View of Rules creation in MATLAB

3.10.19 Rule's view of Sugeno System

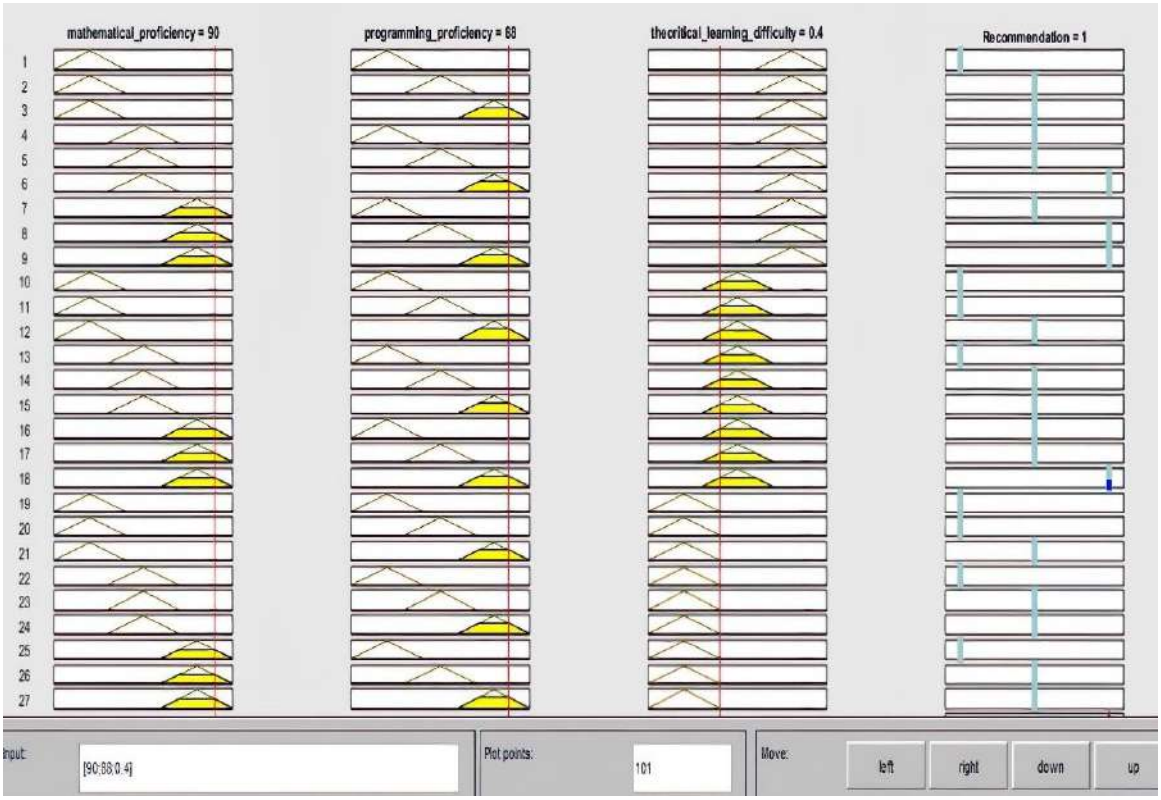


Figure 3.19Rules view of Sugeno System

3.10.20 Surface view of Sugeno System

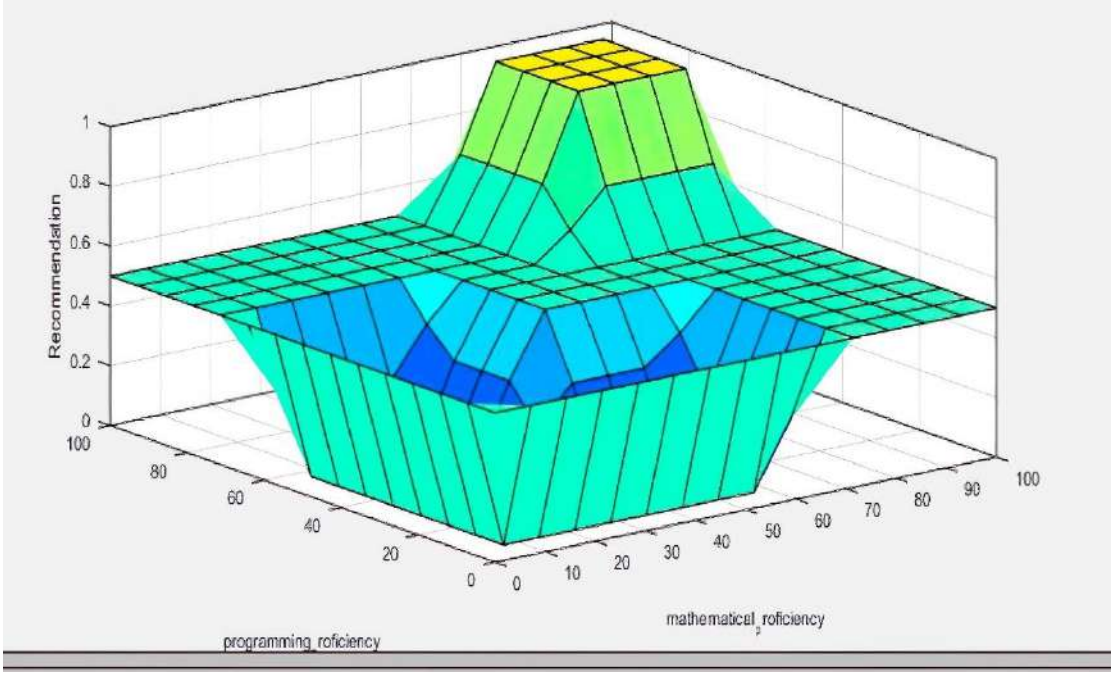


Figure 3.20 Surface view of Sugeno System

Figure 3.20 shows the surface view of Sugeno system.

3.11 Comparison between Mamdani and Sugeno System

We have analyzed both the Mamdani and Sugeno FIS outputs and found that the Sugeno FIS generally produces smoother and more consistent predictions compared to the Mamdani FIS. This is evident from the surface view, where the Sugeno FIS output forms a more continuous and regular pattern.

The Mamdani FIS output exhibits some irregularities and discontinuities, particularly near the edges of the input space. This suggests that the Mamdani FIS may struggle to make accurate predictions in these regions.

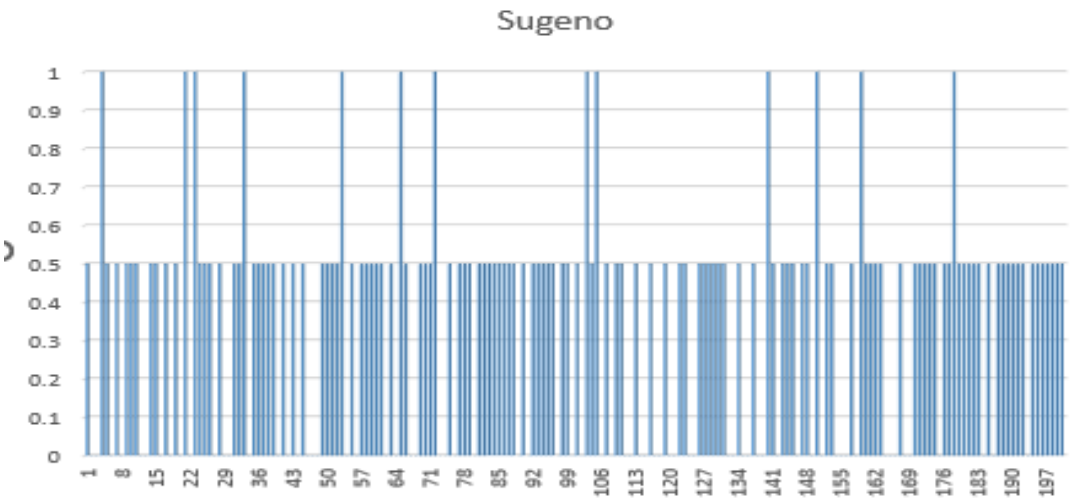


Figure 3.21 Sugeno Outputs plot

Figure 3.21 shows the outputs plot of Sugeno Fuzzy inferencing system.

The Sugeno system determines the required amount of help based on three student parameters: theoretical learning difficulty, programming skill, and mathematics proficiency. The system's result is a number between 0 and 1, where 0 indicates a strong recommendation for support, 0.5 indicates a moderate recommendation, and 1 indicates that little or no more aid is needed.

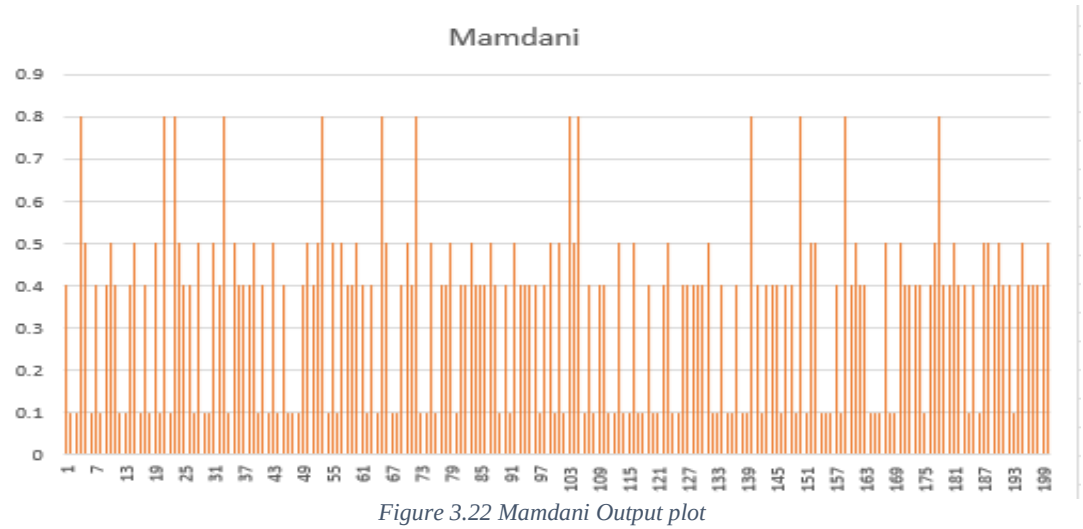


Figure 3.22 Mamdani Output plot

The figure 3.22 show the outputs plot of Mamdani Fuzzy inferencing system

The Mamdani system determines the required amount of help based on three student parameters: theoretical learning difficulty, programming skill, and mathematics

proficiency. The system's result is a number between 0 and 1, where 0.1 indicates a strong recommendation for support, 0.4 indicates a moderate recommendation, and 0.8 indicates that little or no more aid is needed.

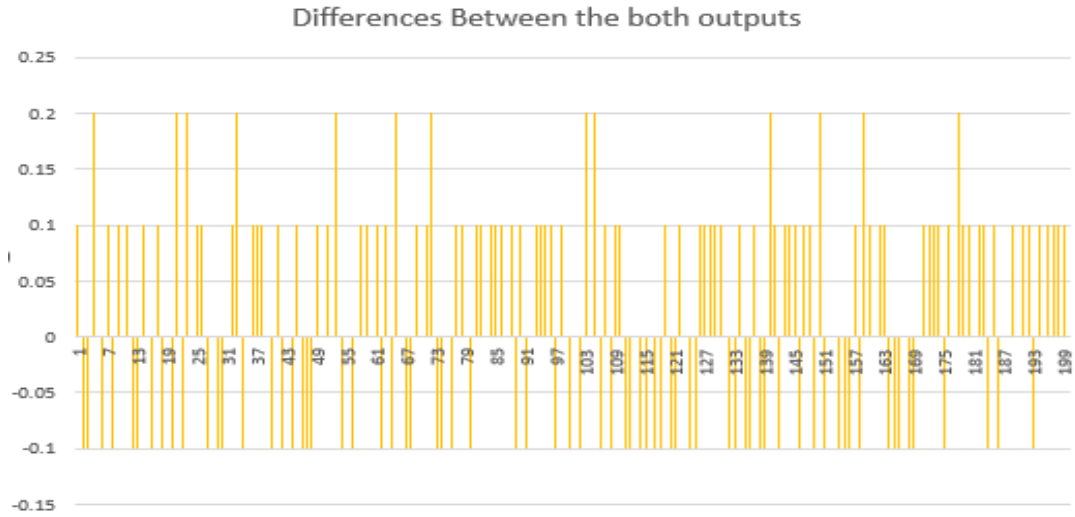


Figure 3.23 Difference B/W Mamdani & Sugeno

Figure 3.23 shows the difference between the Sugeno and Mamdani system.

While Sugeno and Mamdani systems both offer guidance according to student proficiency and difficulty, they may differ in their recommendations. This difference plot shows areas in which they agree (low output difference) and in which they diverge significantly (large difference), most likely as a result of their different inference mechanisms, membership functions, and rule bases. Analyzing these areas of agreement and disagreement can help direct future development, facilitate conversations about system reliability, and ultimately assist in determining which system is best for each individual student within your curriculum.

CHAPTER 4
RESULTS

CHAPTER 4

4 RESULTS

In this chapter we discuss about the result obtained from the Fuzzy logic-based guidance system for student's course level difficulty and analysis also been provided.

4.1 Data Set Used

The dataset used for the Fuzzy logic-based guidance system for student's course level difficulty consists of 200 students' data which was obtained from the students of different departments. We have divided the data in to ratio of 4:1. That we have used 160 students' data to train the system and 40 students' data to for testing the recommendation system.

4.1.1 Training system

80% data was used for training the system and 20% of data was used for testing.
It can be seen the table 4.1 that we have train the system on 160 cases. 128 cases were identified correctly by the system and 32 cases was identified incorrect by the system which give the accuracy of 80%.

Table 4.1 Result of Training

No of samples	Find correct by the system	Identified incorrectly	Accuracy
160	128	32	80%

4.1.2 Testing system

The system was tested on 40 unseen cases. Table 4.2 shows the number of cases of testing data.

Table 4.2 Result of testing

No of samples	Find correct by the system	Identified incorrectly	Accuracy
40	30	10	75%

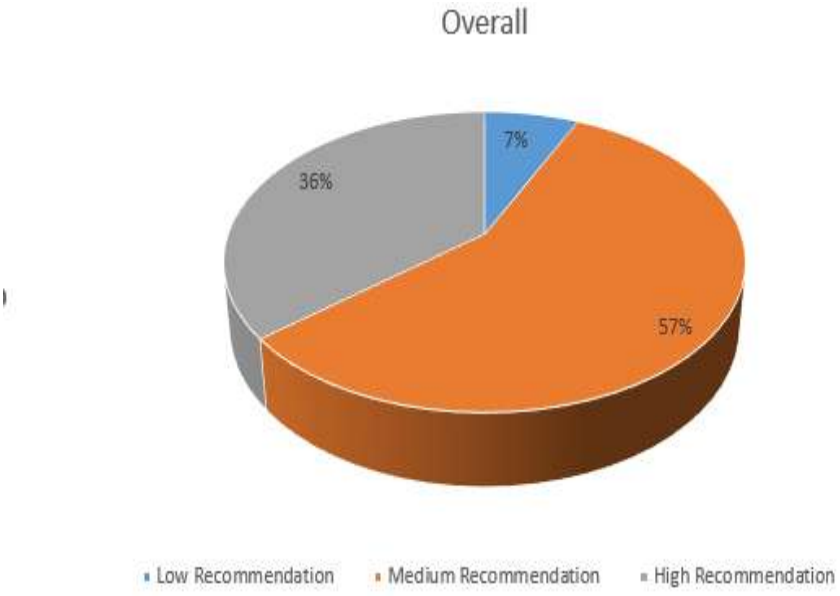


Figure 4.1 Overall responses

Figure 4.1 shows the overall responses in term of percentage of different departments from Balochistan University of Engineering and Technology Khuzdar students. It can be seen in the figure that 57% of students require medium recommendation as they response positive during the interview conducted. And 36% of students require high recommendation because they face many difficulties related to their study. And 7% of students require low recommendation.

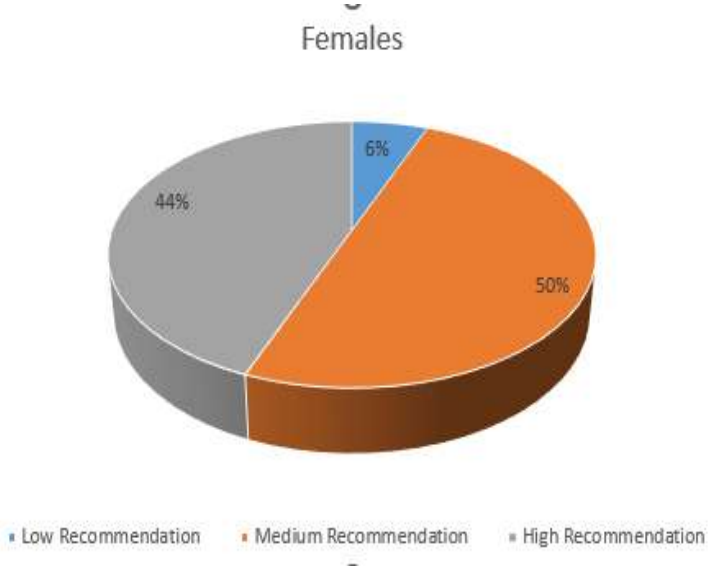


Figure 4.2 Females responses

Figure 4.2 shows the responses of 50 females' students of BUETK from different departments. It can be seen in the figure 4.2 that 50% of female's students require

medium recommendation, 44% require high recommendation and 6% of them require low recommendation according to their course level difficulties.

4.2 Result from different departments

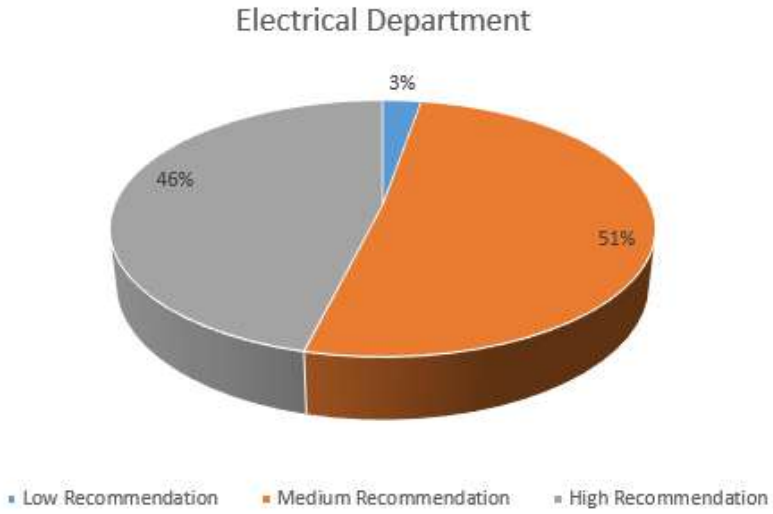


Figure 4.3 Responses of Electrical department Students

Figure 4.3 shows the responses of Electrical department student of BUETK. It can be seen in the figure that 51% students of Electrical departments require medium recommendation, 46% of students require high recommendation and 3% of students require low recommendation. So, it can be seen that most of the students face difficulties in their study.

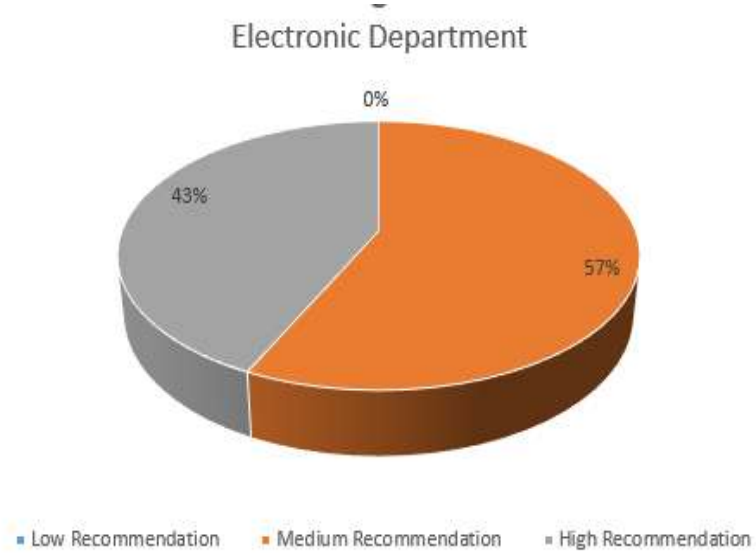


Figure 4.4 Responses of Electronics department students

Figure 4.4 shows the responses of students from Electronics Engineering department of BUETK. It can be seen in the figure that 57% of students require medium recommendation which is greater as compared to Electrical department.

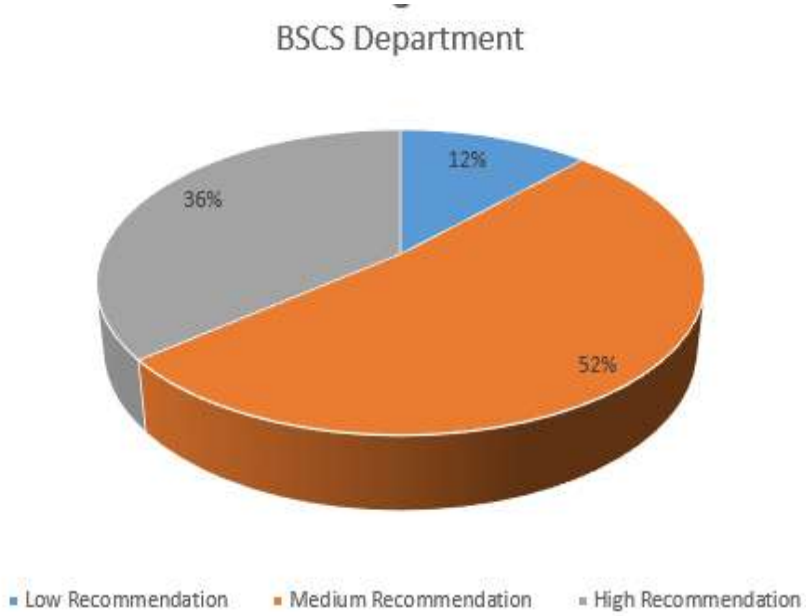


Figure 4.5 Responses of BSCS department students

Figure 4.5 shows the responses of BSCS department students of BUETK. It can be seen in the figure that 52% of students require medium recommendation, 36% of students require high recommendation and 12% of students require low recommendation which is greater number as compared to other departments students.

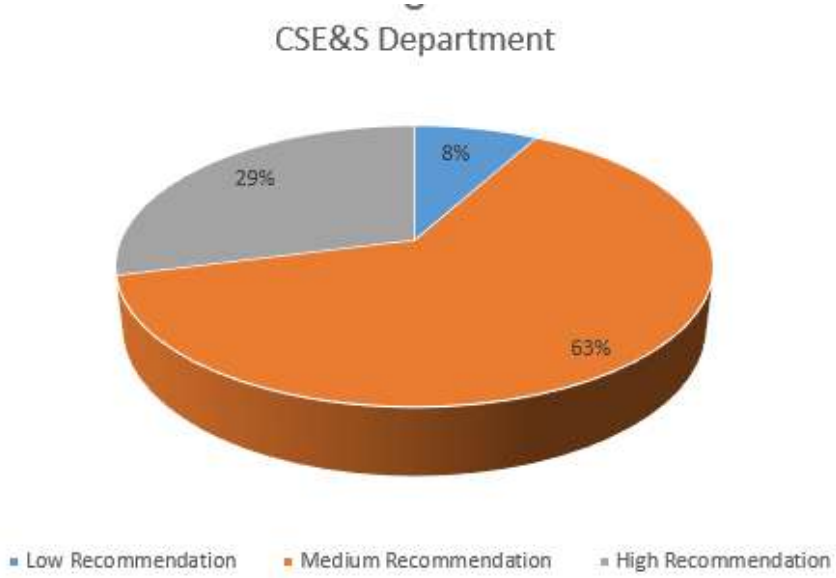


Figure 4.6 Responses of BE. CSE department students

Figure 4.6 shows the responses of BE. CSE departments students of BUETK. It can be seen in the given figure that 63% of students require medium recommendation, 29% students require high recommendation and 8% of students require low recommendations for solving their difficulties.

CHAPTER 5
CONCLUSION AND FUTURE WORK

CHAPTER 5

5 CONCLUSION AND FUTURE WORK

This chapter provides conclusion of the research work carried out, completion status of the objectives, limitations and direction towards future work.

5.1 Conclusion

In this work, we have used the fuzzy logic to develop a guidance system for student course level difficulties. After a detailed literature review and collection of data via structured interviews of different students of different departments of BUETK, three variables were selected to develop the fuzzy inference system. The variables selection was based on a detailed process. After the selection of variables, both Mamdani and Sugeno system was developed and 27 rules were created. The output of the system is the prediction of the input parameters which refer to high recommendation, medium recommendation and low recommendation. The developed system was tested based on holdout set method where 80% of data was used for training and 20% data was used for testing. The results shows that the developed system was able to give 75% correct recommendations. In terms of achieving objectives, table 5.1 shows the status of the objectives.

Table 5.1 Objectives with their completion status

Objective No	Objective	Status
1	To investigate the factors causing problems for students learning and rank them by computational methods.	Completed
2	develop a fuzzy logic-based guidance system that provides recommendations based on students level of difficulty of learning.	Completed

It can be seen from the table 5.1 that both the objectives have been completed. A fuzzy logic-based guidance system was developed that will provide individual recommendations to each student's course difficulty and learning needs and the system was tested on a given dataset.

5.2 Limitations:

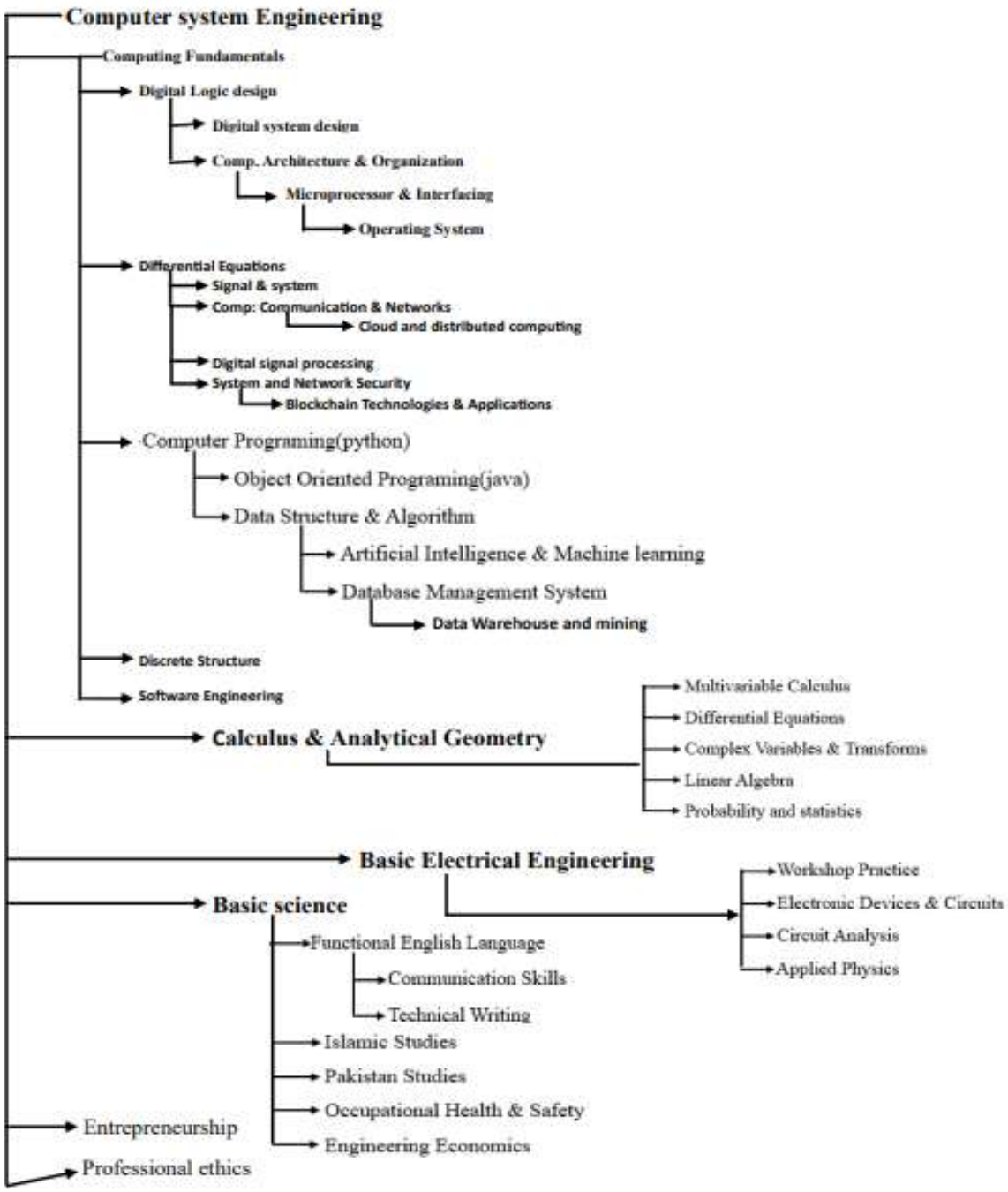
1. The interviews were limited to the students of BUETK.
2. We limited our system to 3 variables, so our system will not be able to address other difficulties that students could face.
3. The absence of a user-friendly application hinders the system's accessibility and engagement among students.

5.3 Future Work:

1. By employing generative AI methods such as GPT-3 or LaMDA, the system may provide customized study tools, adaptive feedback, and learning plans that are suited to the needs and learning preferences of each individual learner. In addition to further personalizing the educational process, this might give students access to more useful and interesting resources to help them meet their academic objectives.
2. The system's capacity to recognize complex patterns and links between student characteristics, learning behaviors, and academic performance may be improved by using deep learning models that have been trained on substantial datasets of student data. A more thorough understanding of student learning may result in more precise suggestions, better student performance predictions, and ultimately, better assistance for specific needs.
3. In addition to the previously discussed areas for future research, a critical component of expanding the system's reach and impact is the development of a user-friendly mobile application for student interaction. This application will serve as the primary interface for students to access the system's features and receive personalized recommendations.
4. Two important data-driven strategies will be the main emphasis of this fuzzy logic-based guiding system's future development. First, course results representing student performance will be added to the system, enriching it further. This will facilitate the development of more precise and useful recommendations suited to each student's academic advancement by providing a more objective and quantitative knowledge of each person's strengths and shortcomings. Second, the curriculum's dependencies and structure will be

examined by the system using course mapping methodologies. This thorough knowledge of the academic environment will enable the system to take into account future programme requirements and routes in addition to current issues, resulting in more strategic and informed assistance.

With the integration of advanced course mapping and rich student performance data, this system has the potential to develop into a highly personalized and influential academic advice tool that will assist students at every stage of their academic journey.



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by Fayyaz Liaqat

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