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ENHANCED APPROACH FOR CHANGE OF COURSE OF STUDY USING FUZZY LOGIC

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ABSTRACT

In tertiary institutions of Nigeria, students are admitted through the Unified Tertiary Matriculation Examination (UTME) to study courses of their choice. However, most students often perform poorly. Thus, the need to change their programme of study becomes a necessity or risk being withdrawn from the university. The student for a change of programme is required to present a cumulative grade point average (CGPA), which informs the student's status and commonly used criteria to determine the student's qualification for a change of programme of study. The students are allowed to choose or advised which programme to choose based on their perceived strength. This is not scientific and have proven ineffective since may be based on biased perception. Thus, most of these students still perform poorly in the new programme of study and may end up being withdrawn. In order to minimize subjectivity and handle uncertainty in such a decision process, this paper proposed a fuzzy logic approach for the change of programme of study by considering the student's Senior Secondary School Certificate Examination (SSCE) result(s), UTME scores, and grades obtained in the various examined and related courses. The CGPA initiates the entire process. The simulation was done in MATLAB, inputs were supplied and the recommendation is generated. The strength values of each input is calibrated from$0-100$, as $0-39, 40-49, 50-59, 60-69 and\ 70-100$ from which the system recommends other faculties, Computer Science, Statistics, Physics and mathematics respectively. The system enhances the chance that a student may perform in their newly proposed programme.

Keywords: CGPA, Change of Course, Fuzzy Logic, Fuzzy Set, SSCE, UTME

INTRODUCTION

In recent years a great concern has been raised on the increase in continuous decline in academic performance in Nigeria Tertiary institution by public commentators in the education sector and all sundry in the sphere of life. For instance the result of 100level in the 2019/2020, 2020/2021 and 2022/2023 sessions of the mathematical Sciences Kaduna University, show that 46% ,38% and 43% respectively, of the students enrolled in the department got a CGPA below 2.0 points which does correlate the entry requirement in both SSCE and UTME.

However, the decline in academic performance have been caused by some unending factors, which have been asserted in various literature see (Weng, *et al* 2009, & Womble, 2003). Student with a CGPA below 2.0 points may be allowed to progress to 200 levels, some likely end up changing their programme of study to other Programmes, others are asked to repeat or withdraw due to some certain criteria which differ from one institution to another. But the question begging for answers is what is responsible for this decline in students' performance or where is the source originating from?

In a quest to answer the above question(s), many scholars have used different research tools to examine the likely factors and many solutions have been offered see (Afolabi *et al*, 2006, Curtis *et al 2007*,Weng, *et al*, 2009 & Lin, *et al*, 2009).

The idea of Fuzzy Logic (FL) system was used to examine student performance, the continuous assessment, class attendance and examination where the input variables mapped together to give clear judgment on the student performance (Abdul, *et al*, 2019). A fuzzy educational grading system was developed to aggregate various test results to a single score per student (Chiu-Keung, 1996). The utilization of FL tools to give students status and to offer positive advice, by considering the GPA, study period and factors to ascertain students standings in the their studies (Muhammed, *et al*, 2019). Fuzzy association rule mining was utilized to assess academic performance of student by correlating students' pre-admission and academic performance to uncover the relationship between academic achievement and post admission academic performance for appropriate advice and handling (Olufunk, *et al*, 2012). FL tool was used to carry out a comparative study of Post University Matriculation Examination (PUME) and the student's present CGPA, these were mapped together as a way to measure high performing students and low performing based on their PUME scores in two subjects and their CGPA and to also served as an indicator to the origin of a students' problem (Peter, 2015).

(Sarfaraz et al 2022), used Hierarchical fuzzy Inference method to develop a roadmap, for supplier's selection for an organization, result indicate that the system, can help in selecting the most appropriate supplier for an organization

Hierarchical fuzzy expert system was utilized to predict performance in an organization between financial and non-financial factors, the results suggest effectiveness in used hierarchical fuzzy method for comparism, (Rathore & Elwakil, 2020).

A hierarchical fuzzy method was used to compare product between complex tariff packages for bank,utilized by the marketing department to choose a partner bank, the method uncover effectiveness of the tools in making comparism between quantities (Mints et al., 2021).

Existing system considered entry requirements and CGPA for a change of programme, but our system consider the entry requirement, CGPA and the strength of student in selected courses, in the first session to recommend a new programme within the selected courses or otherwise.

This paper is organized as follows: following the introduction, as follows: Section 2: Methodology and concept of fuzzy logic, Section 3 ; Results Sample, Section 4:Conclusion.

MATERIALS AND METHODS

Concept of Fuzzy Logic

Fuzzy Set (FS): Let X be the collection of objects denoted by x, then a FS $\underset{\sim}{A}$ in X is the set of ordered pairs, (Zadeh, 1965). i.e.

$$A = \{x, U_A(x)/x \epsilon X\} \quad (1)$$

Where $U_A: X \rightarrow [0,1]$, is the membership function. $X = \{x_1, x_2, \ldots, x_n\}$ is the universe discourse and A, is describe as $A = \left\{\frac{U_A(x_1)}{x_1} / \frac{U_A(x_2)}{x_2} / \ldots / \frac{U_A(x_n)}{x_n}\right\}$ and / is a separator.

Fuzzy Inference System

Fuzzy Inference System (FIS), constitute the expert' knowledge and experience towards designing a fuzzy logic system, which control the mappings of inputs and output on the set of define fuzzy rules (Yager, 1993). FIS has been a tool used to evaluate performance of a system with few inputs, in this problem due to computations of large inputs, the Hierarchical Fuzzy Inference System (HFIS) is employed to drastically reduced the large amount of rules expected in the system to a reasonable amount and at the same time preserved the accuracy behind the logic (Abdulkadir, *et al*, 2019). Fuzzy Inference System mainly consists of four stages namely: Fuzzification, Inference Engine, Rule Base and Defuzzication.

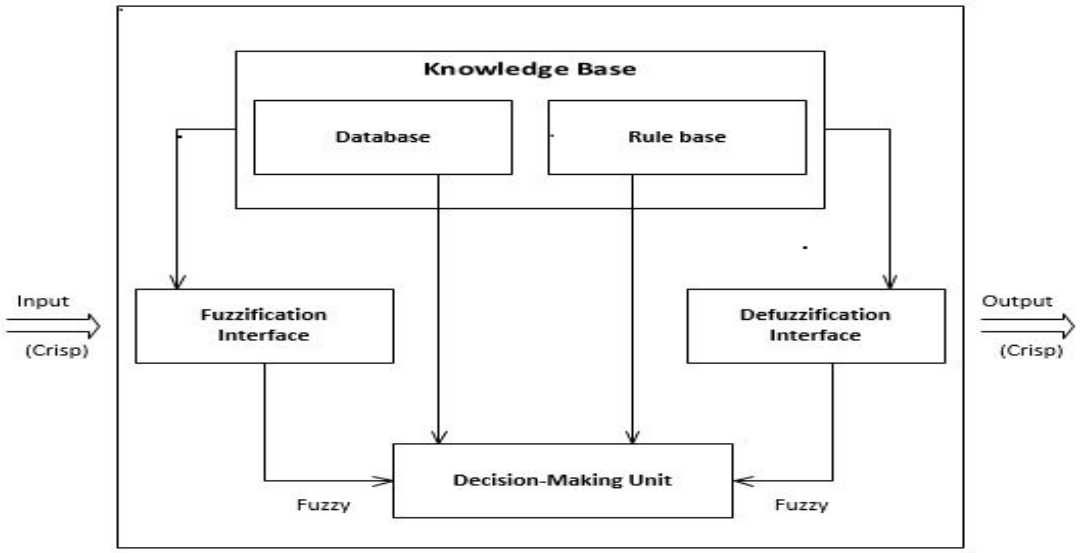

Figure 1: Fuzzy Inference System Model, adopted from Uykur, N., (2019)

Fuzzification/Inference Engine

The fuzzy inference system is described in figure1, where Fuzzification is an important concept in Fuzzy Set Theory, this is a process where crisp value(s) is converted to fuzzy value(s), and this is due to the membership function which mapped real values in a closed interval between 0 and 1, here we utilize the triangular membership function in figure 3, to capture the input for this system which is taken randomly from the student's record available in the various departments and each subject strength is also presented as follows:-

SSCE INPUT: the grades in each of the five entry subjects are aggregated to 100, as $A_1 = 20, B_2 = 17.50, B_3 = 17, C_4 = 14.50, C_5 = 12, C_6 = 9.50, D_7 = 7, E_8 = 2.5, F_9 = 0$.

UTME (U) INPUT: the score in four UTME subjects are converted to a hundred.

CGPA: in this system the CGPA for one session is considered as an indicator to initiate the change from one programme to another within the similarities in courses. A student qualify for a change of programme must earned a CGPA of $0.70\ to\ 1.50$, before enrolled into the process.

SELECTED COURSES STRENGTH: The hierarchical fuzzy structure for this work is presented in figure 2, here we consider similarities in the courses for the choice of the programme across the faculty of science (as physical and natural (others) sciences), We build a system that permit inter switching from one programme to another within the physical sciences, considering similarities in the courses offered, in the first year of study, which can also function effectively in other faculties. The similarities in the courses offered are MTH STRENGTH (MTH101: Sets and Algbra, MTH102: Vector and Dynamics, MTH103: Calculus and Application), STAT STRENGTH (STA101: Introduction to Statistics, STA102: Probability I), PHY STRENGTH (PHY101, PHY102), and CSC STRENGTH (CSC101 Introduction Computer, CSC102: Problem Solving).

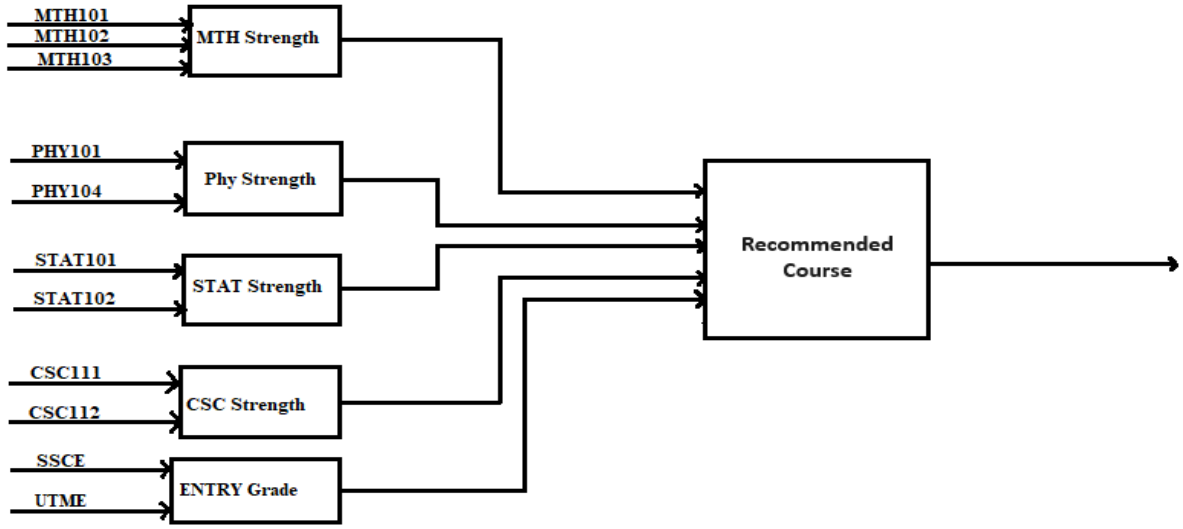

Figure 2: Hierarchical Structure of Implemented Fuzzy System

Table1: Fuzzification of Input Variables

Linguistic Variable	Symbol	Ranges
Low	L	(0,0,40)
Average	A	(40,60,80)
High	H	(60,80,100)

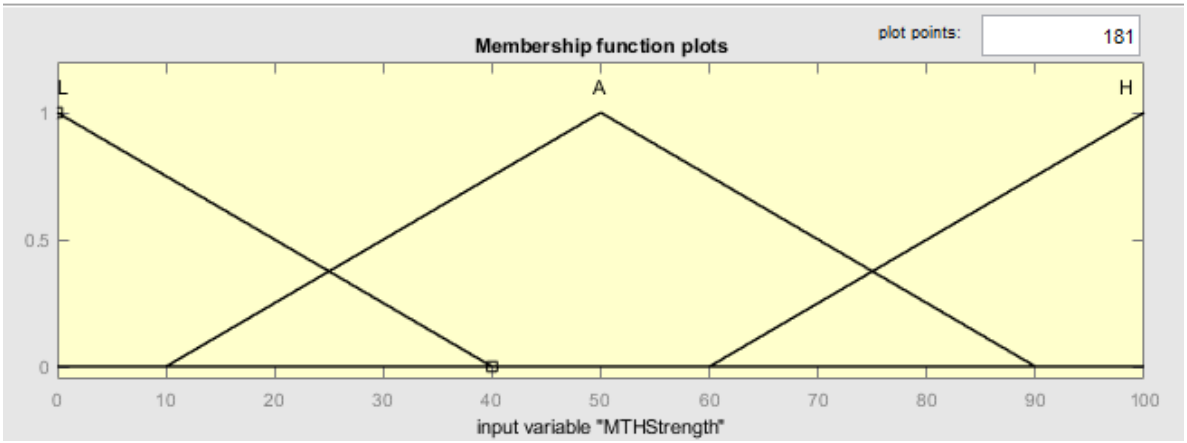

Figure 3: Fuzzy Subject's Strength Membership Function

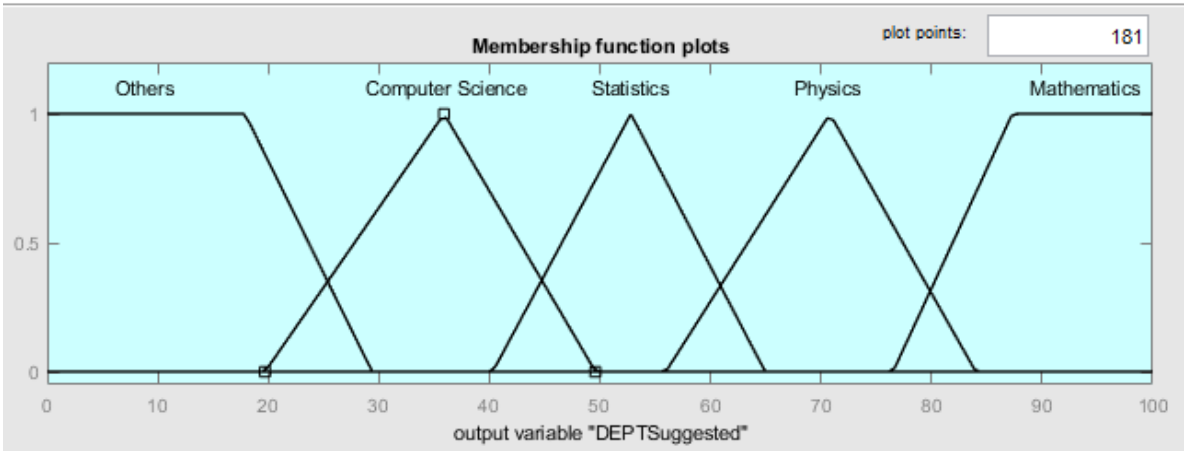

Figure 4: Recommended Course Membership Function

For evaluation of each student strength the "IF THEN", rule, of the fuzzy inference system, which takes fuzzified input as described in table 1, from the database and apply the rule (r) for decision to be taken.

$$U_C(x) = Max_k\{Min(U_A(x_i), U_B(x_j) \dots)\} \quad (2)$$

Where $k = 1,2,3, \dots r$

Here the decision maker can influence a judgment when constructing the rules. A fuzzy inference system with number of input (n) and number of linguistic Variable (v), generates number of rules $r = v^n$ i.e. the "IF THEN" rule. See some of these rules in table2, below:

Table 2: Mathematics Strength Fuzzy Rules

MTH101	MTH102	MTH103	MTH-Strength
L	L	L	L
L	L	A	L
L	L	H	A
L	A	L	L
L	A	A	A
L	A	H	A
L	H	L	A
L	H	A	A
L	H	H	H
A	L	L	L
A	L	A	A
A	L	H	A
A	A	L	A
A	A	A	A
A	A	H	H
A	H	L	A
A	H	A	A
A	H	H	H
H	L	L	L
H	L	A	A
H	L	H	H
H	A	A	A
H	A	H	H
H	H	L	A
H	H	A	H
H	H	H	H

Defuzzification

After process the inference engine, that is generating the rules, the output obtained is fuzzy set, this output cannot provide precise information for the user or operator, as such it is transform from fuzzy to crisp form for easy interpretation of information.

Note that the output of the fuzzy inference system (FIS) can be the union of two or more fuzzy membership function as defined in equation (2), this is expressed algebraically as:

$$U_C(x) = \frac{\sum_{i=1}^{r} f_i U(x_i)}{\sum_{i=1}^{r} U(x_i)} \quad (3)$$

Where $U(x_i)$, is the activated rule and f_i is the composite area of the membership function.

RESULTS AND DISCUSSION

In order to test the developed approach, simulation was done in MATLAB, inputs were supplied and the recommendation is generated. The defuzzified output computed from the fuzzification of the strength values of each input is calibrated from $0 - 100$, and interpreted as

$\mathbf{0 - 39}$ **,** the system recommends others (i.e. other faculty), $\mathbf{40 - 49}$, the system recommends Computer Science, $\mathbf{50 - 59}$, the system recommends Statistics $\mathbf{60 - 69}$, the system recommends Physics $\mathbf{70 - 100}$, the system recommends Mathematics. The implementation of fuzzy system was carried out to reach a decision based on the strength in the requirement for a change of course, as can be seen from rules that measures student's strength in mathematics present in table 2 and the surface plot in figure5. Then the recommended new course for a student is presented in the result sample in table3 and the surface plot in figure6.

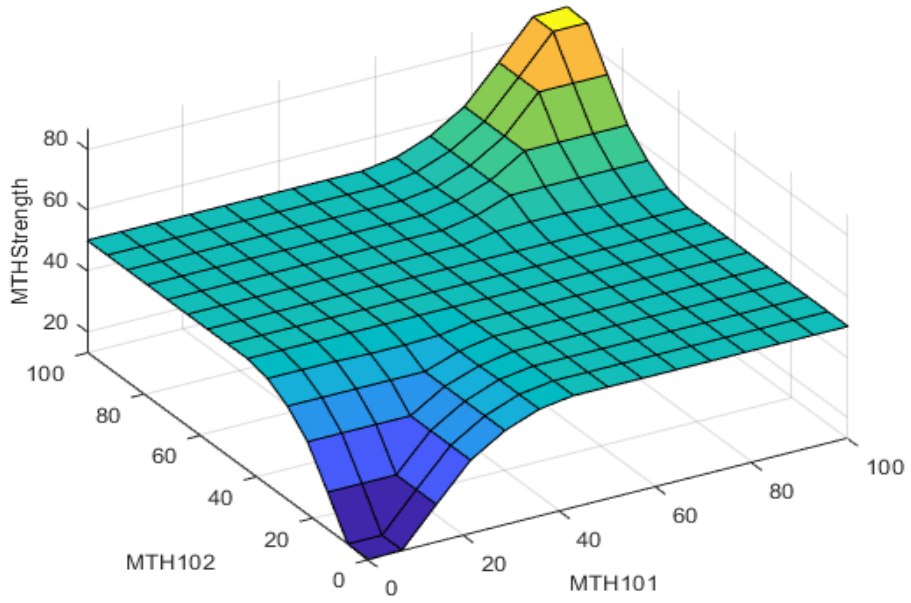

Figure 5: Course Strength Control Surface

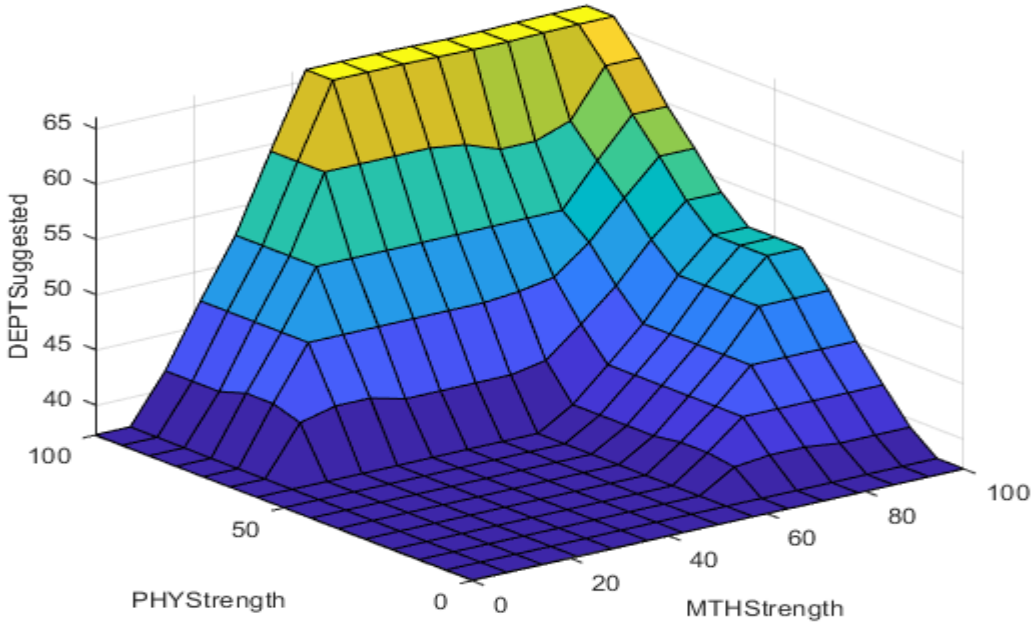

Figure 6: Course Recommendation Control Surface

Table3: Sample of Results

EXPERIEMENT NUMBER	CODE-SCORES	STRENGTH VALUE(S)	DEFUZZIFICATION VALUE(S)	RECOMMENDATION
	MTH101-82 MTH102-91 MTH103-18	MTH STRENGTH 51		
1	PHY101-92 PYH104-64	PHY STENGTH 86		
	STA101-10 STA102-64	STAT STRENGTH 16	41	COMPUTER SCI.
	CSC101-55 CSC102-96	CSC STRENGTH 87		
	SSCE-97 UTME-16	ENTRY STRENGTH 52		

EXPERIEMENT NUMBER	CODE-SCORES	STRENGTH VALUE(S)	DEFUZZIFICATION VALUE(S)	RECOMMENDATION
2	MTH101-85 MTH102-94 MTH103-64	MTH STRENGTH 71		
	PHY101-76 PYH104-75	PHY STENGTH 59		
	STA101-43 STA102-60	STAT STRENGTH 52	68	PHYSICS
	CSC101-18 CSC102-71	CSC STRENGTH 41		
	SSCE-4 UTME-28	ENTRY STRENGTH 15		
3	MTH101-10 MTH102-83 MTH103-70	MTH STRENGTH 47		
	PHY101-70 PYH104-32	PHY STENGTH 51		
	STA101-96 STA102-4	STAT STRENGTH 50	37	OTHERS
	CSC101-44 CSC102-39	CSC STRENGTH 49		
	SSCE-77 UTME-80	ENTRY STRENGTH 62		
4	MTH101-19 MTH102-49 MTH103-45	MTH STRENGTH 50		
	PHY101-65 PYH104-71	PHY STENGTH 55		
	STA101-76 STA102-21	STAT STRENGTH 52	67	PHYSICS
	CSC101-68 CSC102-66	CSC STRENGTH 53		
	SSCE-12 UTME-12	ENTRY STRENGTH 21		
5	MTH101-39 MTH102-57 MTH103-81	MTH STRENGTH 49		
	PHY101-68 PYH104-54	PHY STENGTH 13		
	STA101-78 STA102-94	STAT STRENGTH 84	51	STATISTICS
	CSC101-13 CSC102-52	CSC STRENGTH 23		
	SSCE-47 UTME-2	ENTRY STRENGTH 13		

EXPERIEMENT NUMBER	CODE-SCORES	STRENGTH VALUE(S)	DEFUZZIFICATION VALUE(S)	RECOMMENDATION
6	MTH101-98 MTH102-96 MTH103-49	MTH STRENGTH 86		
	PHY101-81 PYH104-15	PHY STENGTH 47		
	STA101-43 STA102-92	STAT STRENGTH 86	47	COMPUTER SCI
	CSC101-80 CSC102-92	CSC STRENGTH 84		
	SSCE-64 UTME-4	ENTRY STRENGTH 29		
7	MTH101-50 MTH102-49 MTH103-34	MTH STRENGTH 50		
	PHY101-91 PYH104-34	PHY STENGTH 77		
	STA101-12 STA102-79	STAT STRENGTH 45	71	MATHEMATICS
	CSC101-39 CSC102-25	CSC STRENGTH 41		
	SSCE-41 UTME-10	ENTRY STRENGTH 14		
8	MTH101-62 MTH102-86 MTH103-81	MTH STRENGTH 65		
	PHY101-58 PYH104-19	PHY STENGTH 34		
	STA101-24 STA102-89	STAT STRENGTH 87	75	MATHEMATICS
	CSC101-3 CSC102-49	CSC STRENGTH 13		
	SSCE-17 UTME-98	ENTRY STRENGTH 53		

CONCLUSION

The paper explores basic concept of Fuzzy logic and Fuzzy Inference System, to implement the change of programme in tertiary institution in Nigeria, within the same faculty considering similarities in courses offered in the first session. Due to large input the Hierarchical Fuzzy Inference System (HFIS) was utilized to reduce the rules. The system is efficient for processing change programme within the same faculty and can also function in other faculties.

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