An Automated Implementation of Academic Staff Performance Evaluation System based on Rough Sets Theory

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Abstract

The essence of evaluating employees' performance in any tertiary institution is to realize the goals of the institution by measuring the contribution of each employee. Effective human resource evaluation is paramount to the development of any organization. An automated method is needed to remove the limitations and facilitate the duties of human resource management. In this paper, rough set theory, a mathematical technique that deals with vagueness and uncertainty of imperfect data analysis is adopted for the evaluation of academic staff profile for promotion, grants and other academic purposes. The entire appraisal process of academic staff was translated into a web-based application where every user can fill, edit, update, and submit the annual performance evaluation report form. The indiscernible property of rough set approach is a unique factor in assessing every academic staff under the department and faculty/school by the head of department and Dean respectively. With this, the system generates an information table handling all the necessary conditions for promoting academic staff and the corresponding decisions taken. A model for rating publications was proposed to reduce the sentiments involved in manual rating. Reports were generated as output of each evaluation procedure. One hundred (100) dataset of academic staff of the Federal University of Technology, Akure, Nigeria was used in the experiment to evaluate the performance of the system. The results of the system obtained score were compared with the institution standard and it was found that the system scores were above standard, the average precision of the system shows 60% effectiveness which showed that the proposed system is efficient for academic performance evaluation process.

Keywords: Academic Staff, Human resource management, Performance Evaluation, Rough sets

1 Introduction

Human resource management (HRM) in organizations is intended to maximize employees' performance in the service of an employer's strategic objectives (Bratton and Gold, 2017). It is mainly concerned with the management of people within organizations by focusing on policies and systems. HRM is also charged with integrating human resource planning with overall organizational planning (Brewster & Hegewisch, 2017), which includes career development, training and compensation. Others are performance evaluation, promotion, transfer and employee discipline (Collings & Woods, 2018). In order to accomplish the organization's goals and support the organization strategies, human resources objectives and strategies must be developed. Evaluation of staff is done manually by the HRM in tertiary institutions and this manual evaluation process is laden with inconsistent reports and its procedure lack standards. Evaluation of employees of organizations (Safarzadeh et al. 2014, Gbadebo & Adebayo, 2017) is a subtask of the human resource management, as such evaluation of the academic staff's activities is conducted by this management and it is based on curriculum vitae assessment. The guidelines of this assessment are always aligned with the mission and goals of the institution in order to contribute towards its success. Academic staff members' evaluation has potentially dual impact on the performance of the institution and on individual staff members' activity orientation and performance, given the effect on their career and progression in life (Neogi et al. 2011, Ranjan et al. 2015). Human resource evaluation is an optimization problem and a multiple criteria decision making process. It is therefore usually impossible to deal with a decision in terms of a single criterion (Liu & Wei, 2000), bearing in mind that not every evaluation technique (Widayati, 2013) is appropriate for a specific problem domain. A suitable technique must be applied to a particular situation to achieve the institution's objectives. The evaluation techniques are divided into two categories: the objective and the subjective methods. The objective technique evaluates decisions mostly based on numerical data, thus conclusion can be fairly supported without any ambiguity. The subjective decisions need to be objectified by means of multi-criteria evaluation techniques (Liu & Wei, 2000). According to Samuel et al (2014), computing tools help to organize, store and retrieve appropriate knowledge needed by HRMs to deal with difficult managerial problems and provide appropriate decision support platforms for them. In this paper, the major criteria of evaluation are aggregated by a mathematical relation and the result of the aggregated value is used with other conditions for promotion via rough set theory (Cekik .& Telceken, 2018) which is implemented with hypertext pre-processor (PHP) for effective automated method that reduces sentiment in publication scoring while evaluating academic staff profiles.

2 Related works

Several works have been carried out on the performance evaluation of employees in institutions. Some of the techniques of evaluation used are discussed as follows.

Islam & bin Mohd Rasad, (2006) used analytic hierarchy process (AHP) to simplify complex evaluation problems into structural hierarchies. The major evaluation criteria were first identified, and consecutively subdivided into hierarchical levels. The weaknesses of the system are, it requires expert choice software to compute the weights of the criteria and sub-criteria and it also requires substantial amount of time to obtain the overall performance scores.

Neogi et al. (2011) proposed a system that was based on the articulation of cascading fuzzy inference system and centre of gravity (COG) defuzzification method. The Fuzzy Inference System (FIS) module contains five FISs sub-modules in cascade named fuzzy communication block. The major weakness of the work is that an expert can easily modify the system's inputs, including the set of fuzzy rules

Fullér et al. (2012) applied different fuzzy ordering techniques with fuzzy number to order the candidates, in order to help manager decide whether to employ, retain or reallocate employees according to the level of their performance. The operation of the system is limited to hiring and reallocation of employee, other functions of human resources management were not considered.

Okoye et al. (2013) applied neural networks to resolve some observed manual weaknesses, particularly in view of neural networks' ability to learn and adapt, to resolve conflicts by collaboration, propagation and aggregation. Numerical methods capable of analysing dependence structure of a multivariate population were used. Human resource management metrics were used as the data modelling tool for evaluating performance of academic staff based on three main factors, namely: research, teaching and service. However, the flaw of the work is that the system developed used neural network model which cannot handle linguistic and vague information.

Bhosale & Kamath (2013) developed a fuzzy inference system for different modules. The three modules include: fuzzy module for Teaching, learning and evaluation related activities; Fuzzy module for Co-curricular, Extension, Professional Development Activities, and Fuzzy module for Research, Publications and Academic Contributions. The system used the fuzzification method which comprises of the process of transforming crisp values into membership grades. The membership function is used to associate a grade to different linguistic terms. The weakness exhibited by the system is that it requires human experts to discover rules about data relationship.

Samuel et al (2014) made use of fuzzy logic based on the concept of fuzzy set theory, fuzzy if-then rules, and fuzzy reasoning to model an expert system for human resource performance appraisal. However, the dataset used in the system were limited to the staff under consideration for promotion to senior lecturers alone, other staff were not considered and multiple users cannot access the system at the same time.

Macwan & Sajja (2013) used fuzzy evaluation techniques to facilitate the performance appraisal process, the fuzzy logic allows reviewers to express themselves linguistically and draw definite conclusions from vague, ambiguous or imprecise information. The evaluation parameters used were not all equally important to organization levels.

Jamsandekar & Mudholkar (2013) applied fuzzy inference technique in place of traditional approach to classify student scores according to the level of their performance, fuzzification of the input data was done by creating fuzzy inference system (FIS) subject wise. The model however requires human expert to discover rule about data relationships as student's performance evaluation needs intelligent adaptive and tutoring internet based system.

Banerjee & Ghosh (2013) utilized fuzzy analytic hierarchy process with PROMETHEE-2 and TOPSIS to recruit the best faculty in order to provide quality education to their students. The limitation of the work is that it focused on one particular faculty.

Avazpour et al. (2013) applied fuzzy hybrid multiple criteria decision making approach with combination of different assessors' opinions on fuzzy AHP method for determining the weights of criteria. The weakness of the work is that it cannot be applied to academic staff evaluation

Huang (2014) employed high-order confirmatory factor analysis (CFA) method to evaluate the performance appraisal system of *procurators* by fuzzy comprehensive evaluation method based on the 360 degrees. The weakness of the system is that it does not constitute significant role in segmenting the appraisal indicators in order to enhance the operability of the indicator within system.

Nápoles et al. (2014) used a decision-making model called Rough Cognitive Networks which combines the capability of Rough Set Theory for handling inconsistent patterns, with the modelling and simulation features of Fuzzy Cognitive Maps. The system is however exclusively designed for addressing decision-making problems concerning public transportation issues.

The overall observation of former works shows that the system that are based on fuzzy logic and other existing techniques are prone to different problems restriction in the function of the system as well as slow response time which results in performance degradation of the entire evaluation process. Therefore, there is a need for a fast and robust system that can support the entire evaluation process of any tertiary institution dealing with all the flaws of conventional techniques.

3 System Design

The architecture of the proposed system has been designed in such a way as to allow easy interaction between the system and its users. The system is also designed in such a way that it can support the entire evaluation process of any tertiary institution by dealing with all the shortcomings of the conventional approach. The general architecture of the proposed system is described in Fig. 1.

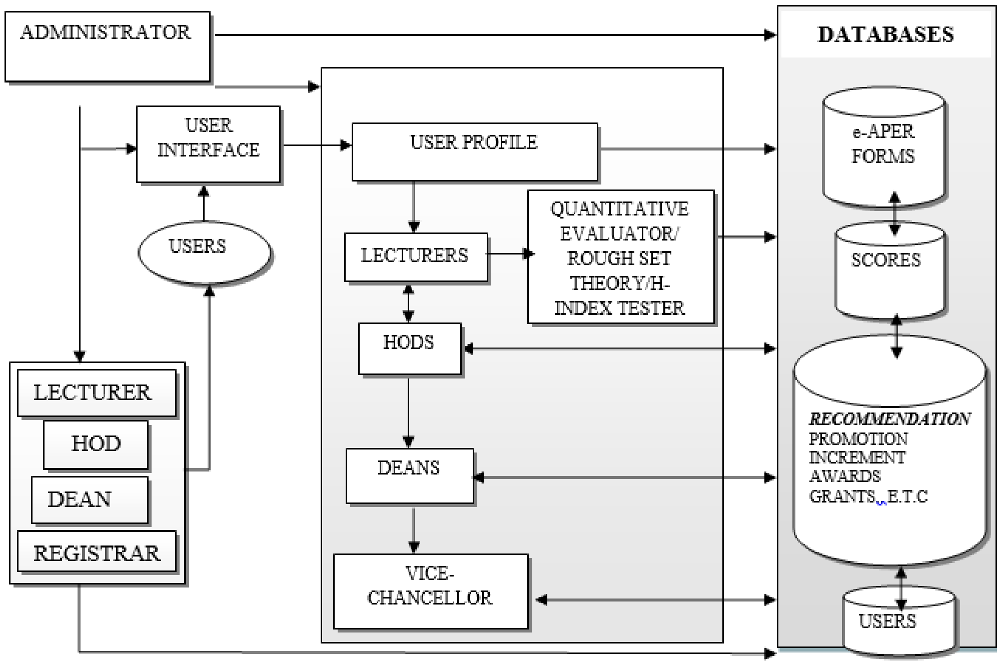

Figure 1: Architecture of the Proposed System

3.1 The Process of the Proposed System

The *Administrator* is responsible for creating accounts for all categories of users in the system and he also has full control of how the system works. There are five major users of the system. The: Administrator, Lecturer, HOD, Dean and the Vice-Chancellor. The users use the *system interface* to access the system to check the authenticity of the user whether he/she is an authorized academic staff or not. When the authenticity of user has been confirmed, then the users' profiles become active. The *user profile* stores the details of the five categories of users on the system. A *lecturer* accesses the system with his username and password, fills the electronic annual performance evaluation form and submits it for assessment. He checks the submitted form after Evaluator1 which is the HOD might have commented, he acknowledges the comment of the HOD and comments where necessary and re-submits for recommendation and approval. It is only the lecturer that can edit his/her profile, other users can only pass comments or approve recommendations based on the information provided in the form submitted. The *HOD* accesses the system through the user interface with his username and password. He also fills his assessment information. The HOD has access to all the information filled by all the lecturers in his department. He can view their all personal information. He then uses the information filled by the lecturers to prepare his assessment. Submitted data will be accessed by evaluator1 (the HOD) for assessment in the relevant areas. The *Dean* accesses the system via the user interface with his username and password. The Deans have access to all the departments in his school/faculty as well as the information filled by the lecturers. The Deans also have access to the lecturers assessment carried out by each head of a department. He then recommends the lecturer for any of the following: confirmation of appointment to retiring age, termination of appointment, promotion or annual increment and also the justification for such recommendations. Finally, the Vice chancellor accesses the system through the user interface with his username and password. He has access to all the faculties in the university and also the information filled by all lecturers, the assessment carried out by the head of the department and the recommendations of the Dean. He then approves the recommendations on behalf of the A&PC.

3.2 Quantitative Evaluator

The system auto-generates the quantitative scores for each academic staff based on the approved rules governing employee promotion of an institution. The quantitative evaluator aggregates all the obtained values of the score and stores it in the appropriate section of the electronic annual performance evaluation form in the database using the mathematical relation below:

$$\mathbf{S}_k = \sum_{i=1}^{n} X_i \qquad 1$$

where S_k represents a given criteria considered when evaluating the performance of an academic staff and k = 1, 2, . . . , m. where m represents the number of criteria for evaluation. For every S_k, there are set of sub-criteria, X_i, where i = 1, 2. . . n where n is the number of sub-criteria present in S_k. The sum of all S_k is the quantitative score of all the criteria which is used by the second part of the model, described in the following sub-section

3.2.1 The Rough Set Model

The rough set theory (RST) (Zhang et al. 2016, Gigović et al. 2017, Pamučar et al.2017) was used to compute all the necessary conditions for promotion such as quantitative score (Sk), number of journal published, number of referred proceedings, number of journal published offshore, PhD status and so on that were used in the proposed academic staff profile evaluation system.

$$Ţ = (U, \Omega, V_q, f_q) \quad q \, Ɛ \, \Omega \qquad 2$$

where U is a finite set of staff to be evaluated, U = {x_1, x_2, …..x_n}, where x_i represents each of the academic staff. Ω is a finite set of attributes (features), which represents conditions for promotion and decision taken, the attributes in Ω are further classified into disjoint set, condition attribute A and decision attributes D.

$$\Omega = A \cup D, \text{for each } q \, Ɛ \, \Omega \qquad 3$$

where A represents conditions for promotion when evaluating an academic staff. D represents decision that should be taken when evaluating an academic staff. ∪ in equation (3) represents union of the two disjoint sets of attributes. V_q is a set of attribute values for q, for example the actual value for quantitative score of an academic staff.

$$f_q: U \rightarrow V_q \qquad 4$$

f_q represents an information function that assigns a particular value from domain of attributes to objects (academic staff) such that:

$$f_q \, (x_i) \, Ɛ \, V_q \, \forall \, x_i \, Ɛ \, U \text{ and } q \, Ɛ \, \Omega \qquad 5$$

(R_q) indiscernibility relations with respect to a given q Ɛ Ω, the functions partitions the universe into a set of pair-wise disjoint subsets of U.

$$Rq = \{x: x \, Ɛ \, U \wedge f(x, q) = f\,(x_o, q) \, \forall \, x_o \, Ɛ \, U\} \qquad 6$$

Let a subset of the set of attributes, P ⊆ A. Two samples x and y in U are indiscernible with respect to P if and only if $f_{(x, q)} = f_{(y, q)}$ ∀ q Ɛ P. The indiscernibility relation for all P ⊆ A is written as IND(P).U/IND(P) which is used to denote the partition of U given IND(P) as follows

$$U/IND(P) = \otimes \, \{q \, Ɛ \, P: U/IND\,(P)\,(\{q\})\} \qquad 7$$

Where

$$A \otimes B = \{X \cap Y: \forall \, q \, Ɛ \, A, \forall \, Y \, Ɛ \, B, X \cap Y \neq \{\}\} \qquad 8$$

⊗ represents Boolean function (∪, ∩) used to compute elementary set of P. The indiscernibility relation is adopted to handle academic staff having similar records of attributes for evaluation purpose. For example two or more staff in senior lecturers' cadre and in same department must meet the same condition for promotion to readers' cadre and so on. The RST use decision rules which are defined to be statements of the form "if C then D", where the condition C is a set of elementary conditions connected by "and" and the decision D is a set of possible outcomes connected by "or". The decision gives us the overall performance of the academic staff.

From equation (3), A is a set of condition attributes compulsory for promotion of an academic staff with the corresponding range of values and labels and it is presented in Table 1.

Label	Attributes	Range of Values
A_1	Quantitative score for each academic staff	1 - 100
A_2	Number of journal papers published	0 - 500
A_3	Number of referred proceedings	0 -500
A_4	Number of journal papers published offshore	0 - 500
A_5	PhD status of an academic staff	0 or 1
A_6	Current level of an academic staff	1 – 6 (GA, AL, LII, LI, SL, RD)
$D = A_7$	Class of decision	1 – 6 (AL, LII, LI, SL, RD, PROF)

Table 1: Conditions and Decision Attributes of an Academic Staff

Note: Each condition consists of seven features along with a label that denotes its decision class; with an instance of one of six possible classes: Assistant lecturer, Lecturer II, Lecturer I, Senior Lecturer, Reader or Professor.

D is a set of decisions to be taken after carefully considering the needed attributes, A for promotion. NQ represents not qualified. D_1 represents promotion to Assistant lecturer (AL), D_2 represents promotion to Lecturer II (LII), D_3 represents promotion to Lecturer I (LI), D_4 represents promotion to Senior Lecturer (SL), D_5 represents promotion to Reader (RD), and D_6 represents promotion to Professor (Prof). Y_1 represents staff on graduate assistant cadre, Y_2 represents staff on assistant Lecturer cadre, Y_3 represents staff on Lecturer II cadre, Y_4 represents staff on Lecturer I cadre, Y_5 represents staff on senior lecturers' cadre and Y6 represents staff on readers' cadre which is presented in Table A1 (Appendix A1) with conditional values of attributes.

3.2.2 Classification of Criteria

The criteria identified in this research work for the evaluation of academic include: Qualification (Q), Research and Publication (R), Teaching/Professional duties (T/pd), Length of service since last promotion or appointment (Ls), and Contribution to the University and Nation (C) with assigned scores shown in the Tables 2-5.

Criteria 1 (S_1)	Attribute	Scores (15)
Qualification	B.Tech or B.sc	6
	M.Tech or M.sc	7
	M.Phil	8
	P.hd	10
Total qualification		= Highest qualification score + (no of professional qualification /100 *5)

Table 2: Qualification Score

$$\text{Research and publication score} = \sum (J/2) + G + H \quad (9)$$

$$J = u + m + (\%\, c)\, {*}\%\, c \quad (10)$$

$$J = u + m + (\%\, c * 0.3) * \%\, c \quad (11)$$

where G represents number of M.Tech/PhD Supervision (Ongoing)*0.5, H represents the number of Research in progress *0.5 and J represents the total sum of journals or proceedings scores which is represented in the algorithm below, where u represents score of authors' position, m represents off/onshore score, c represents percentage contribution when it is a journal and when it is a proceeding, percentage contribution is multiplied by 0.3 to scale down the score of proceeding to maximum of two. However, the system auto generates scores for the other criteria according to the scores shown in Tables 2, 3, 4 and 5.

Criteria 3 (S_3)	Attribute	Scores
Teaching/Professional duties	Professor Reader Senior Lecturer Lecturer I Lecturer II Assistant Lecturer Graduate Assistant	23 21 19 18 17 16 5

Table 3: Teaching and Professional Duty Score

Criteria 4 (S_4)	Attribute	Range of Scores
Length of Service	Current Year – Year of last promotion	$X_i < 2$ $2 \leq X_i < 5$ $X_i \geq 5$

Table 4: Length of service Score

Criteria 5 (S_5)	Attribute	Scores
Contribution to the University and the Nation	Professor Substantive HOD /Reader/ Dean Ag HOD /Exam Officer/PG Rep/School Rep Others	4 3 2 1

Table 5: Score on Contribution to the University and the nation

3.2.3 Conditions Necessary for Promotion of an Academic Staff

There are quite a number of conditions that are necessary for promotion of academic staff from one level to another level in terms of the minimum numbers of papers required, where the paper is to be published and also the minimum quantitative scores required in moving an academic staff from one Level to another which the system considered. The System checks if the academic staff satisfies the necessary conditions for promotion with the conditional statements of the rough set theory using the relation below to compute the elementary set. This relation is a single module used by rough set to determine the status of each academic staff using the system. Sample of the algorithm for the conditions are indicated as follows:

Algorithm for conditions of academic staff promotion

```
IF (quantitative score ≥ "22") AND
(Number of paper ≥ "0") AND
(Referred proceedings ≥ "0") AND
(Number of offshore publication ≥ "0") AND
(PhD status ="1") AND (Employee cadre = "2") THEN
     Employee is qualified for promotion to Lecturer II
```

```
Else IF (quantitative score ≥ "22") AND
(Number of paper ≥ "1") AND
(Referred proceedings ≥ "1") AND
(Number of offshore publication ≥ "0") AND
(PhD status ="0") AND
(Employee cadre = "2") THEN
     Employee is qualified for promotion to Lecturer II
ELSE
     Employee not qualified for Lecturer II
End IF
…..
…..
End
```

The system allows the evaluators to select the appropriate attributes and values that are necessary for awards, grants, and other academic purposes based on the performance of the academic staff either by quantitative score, impact on journal publication and so on.

4 System Implementation

The essence of the implementation phase is to translate the system design into source code. Each component of the design is implemented as a program module that works together to achieve the aim of the research. All program codes were implemented using HTML (Dreamweaver) with CSS, PHP, JavaScript and MySQL. The HTML and the CSS tags were employed to structure the outlook of the web pages in the system, while Java Script codes were introduced to validate the data entered on the designed web pages. PHP has its Object Oriented features combining those of Java and C# languages. It runs faster than Java with higher speed. It is extremely easy to use in developing complex web applications, in a considerable period of time. PHP is also a scripting language with a large amount of users worldwide (Kelvin et al. 2012). The Local host environment characterized by Windows Apache, PHP, MySQL (WAMP) Server was adopted in the work. Windows operating system, Apache HTTP Server, MySQL relational database management system (RDBMS), and PHP programming language. (WAMP) is a model of web service, which is an open source application that allows users to run web based applications on their local machine just the same way the applications behave in an Internet environment.

4.1 System Implementation Results

Some of the screenshots of the system implementation for the evaluation of academic staff are presented. Fig. 2 shows the log in page. The login page is the first page that is displayed to the user of the system. This page is necessary to control and manage the various types of users in the system

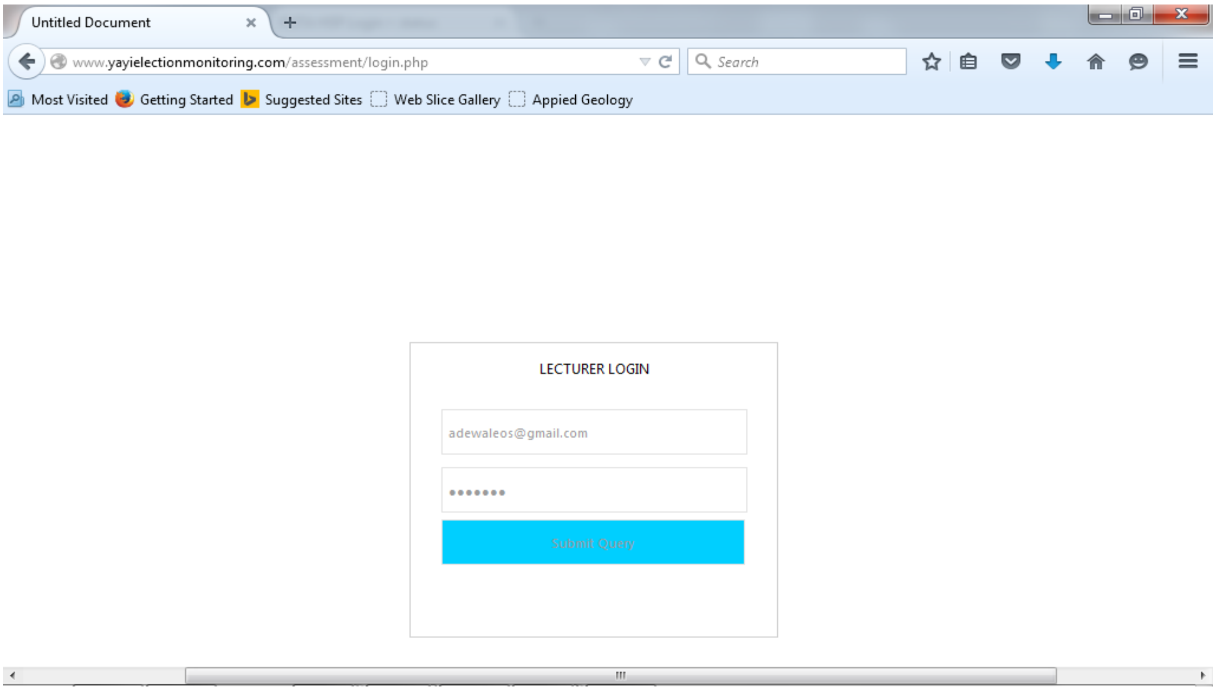

Figure 2. Login page

The publication list page is shown in Fig. 3. It is where the system accepts all the various publications of an academic staff ranging from thesis, articles that have appeared in learned journals, papers already accepted for publication and published conference proceedings.

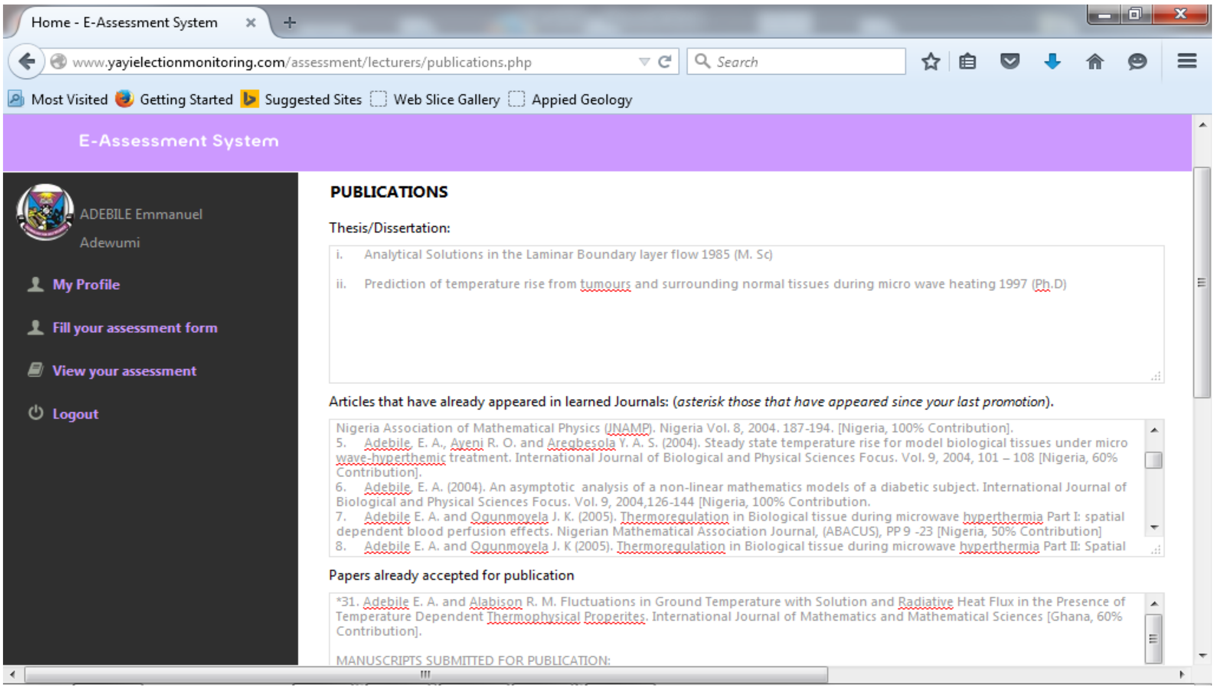

Figure. 3. Publication List Page

Fig. 4 shows the profile of the head of department, showing the details of lecturers whose profile could be evaluated and recommended for promotion or incremental as the case may be.

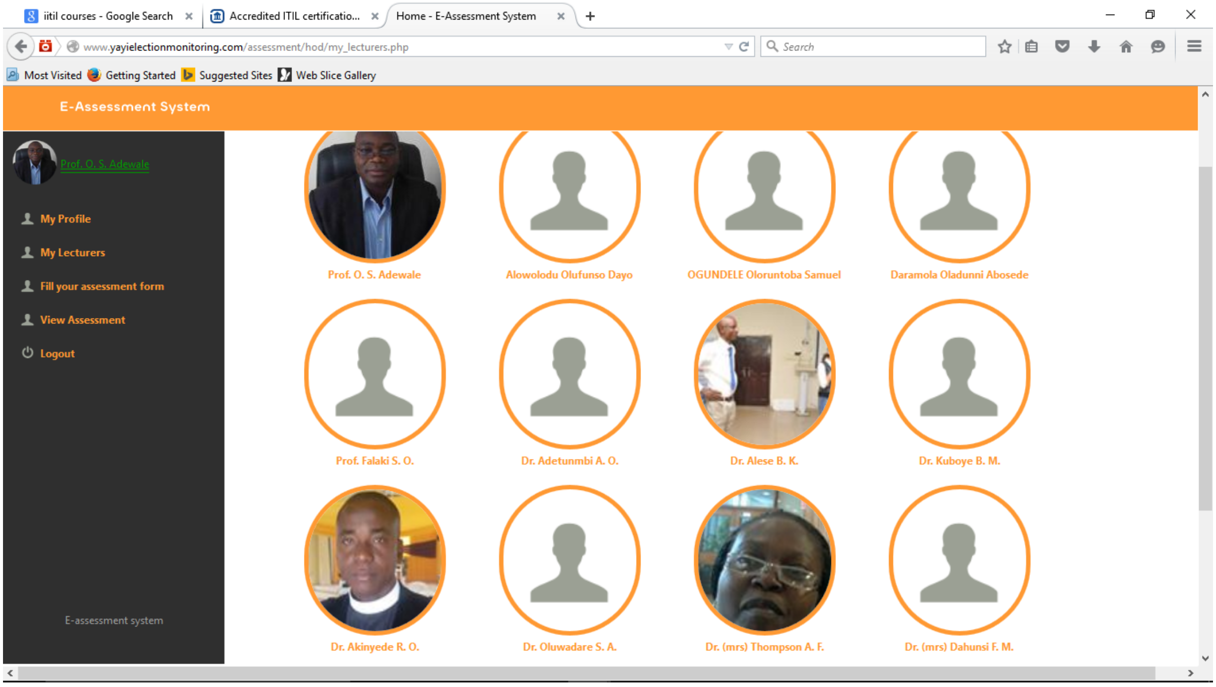

Figure. 4. Lecturers under a particular HOD (Evaluator 1)

The assessment of a Lecturer by the Dean and remarks given is shown in Fig. 5.

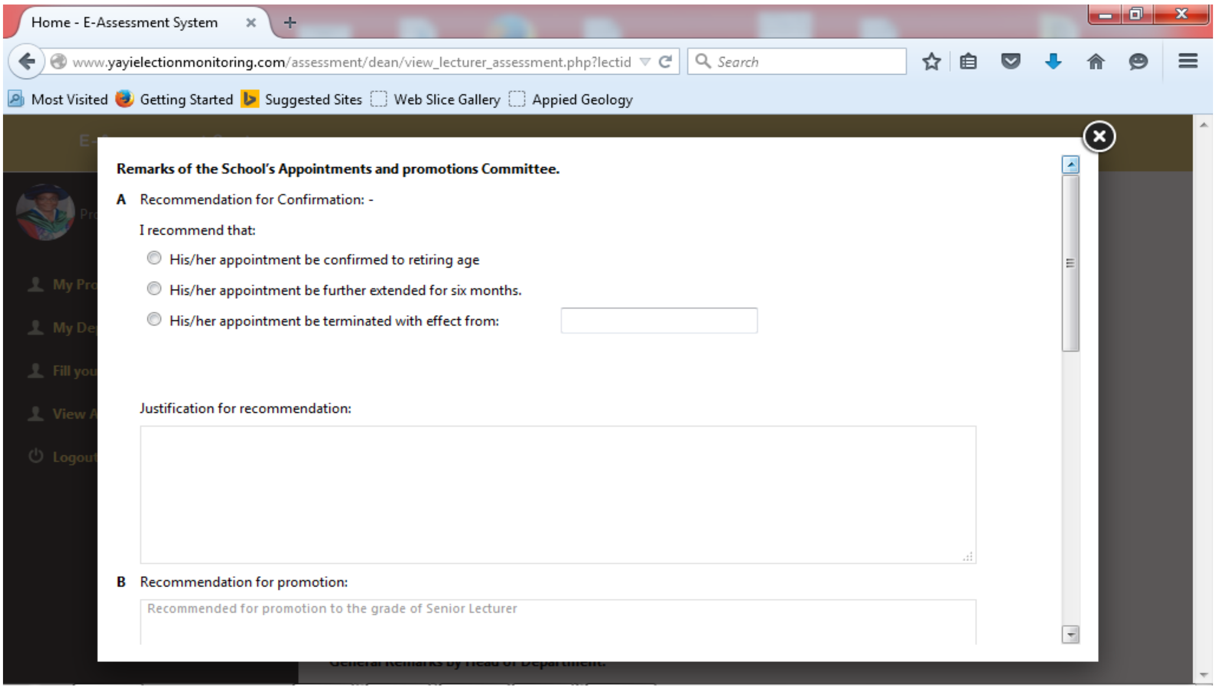

Figure 5. The Recommendation of the Dean on a Lecturer

The page where the administrator login to the system to access it at the backend is shown in Fig. 6. The administrator has the ability to update the database from time to time in order to get the new academic staff added to the evaluation database.

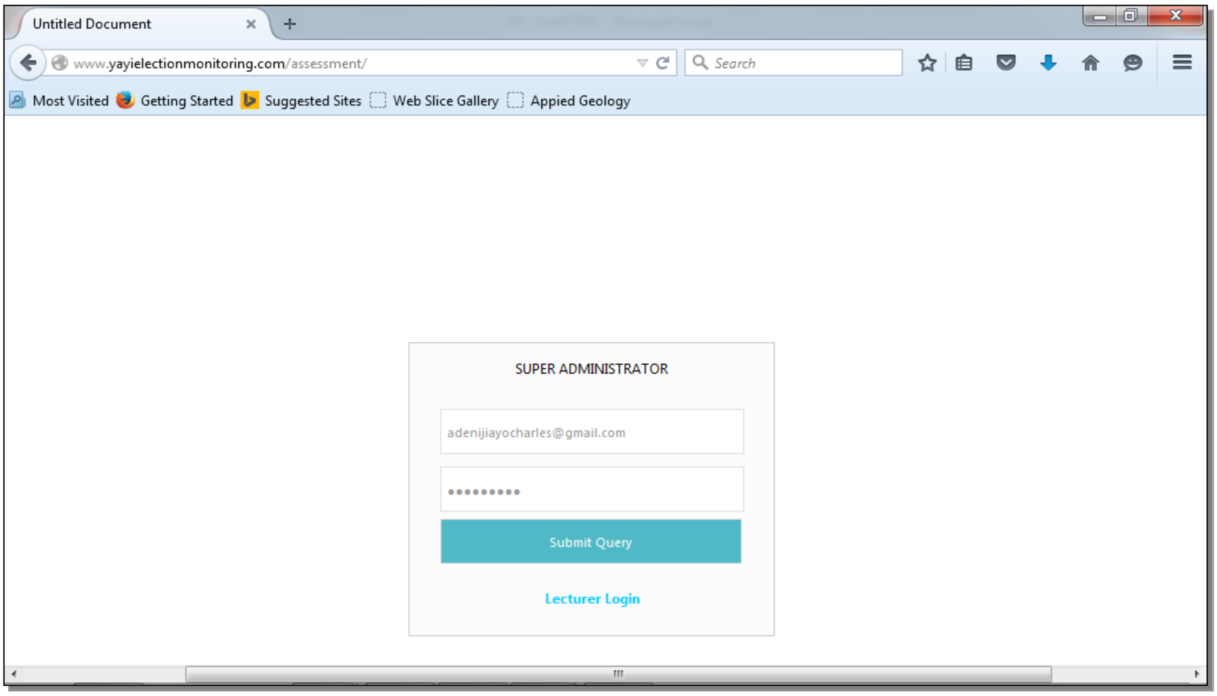

Figure 6. Administrator Login Page

4.2 Experimental Evaluation of the System

The experimental evaluation of the system was done with data collected from manual annual performance evaluation report. In the evaluation of the system, the dataset of an academic staff of different cadre was used and the quantitative score given by the system, current cadre, number of Journals published, PhD status, users (U) and number of publications offshore were considered. An academic staff that satisfies all the necessary conditions for promotion is automatically recommended by the system for promotion into the next cadre while those who are not qualified for promotion are recommended for step increment by the system. It is observed that some users of the system score above the FUTA standard score but they were not promoted due to other important conditions for promotion that they did not satisfy.

4.2.1 Evaluation Metrics

The evaluation of the system was conducted using standard deviation metrics as a system of statistical procedure for the comparative analysis of the performance of user in any institution and also using equation 13, (Akinyokun, 2002).

$$\sigma = \sqrt{\sum \frac{(X-\mu)2}{n}} \qquad 13$$

x represents each user in the department, **μ** is the mean of the values, n represents number of values.

The Standard score $D_{i.k.j}$ of a human resource at the department is defined by

$$D_{i.k.j} = M_{i.k} + (d_{i.k.j} - a_{i.k}) \,/\, S_{i.k} \qquad 14$$

Where $M_{i.k}$ represents the minimum score required by a user in the k^{th} cadre of i^{th} department.

$d_{i.k.j}$ represents the obtained score of the j^{th} user in the k^{th} cadre of i^{th} department.

$a_{i.k}$ represents the mean of the obtained scores of all the staff in the k^{th} cadre of i^{th} department

$S_{i.k}$ represents the standard deviation of the raw scores of all the staff in the k^{th} cadre of i^{th} department.

Using equation 13, all users that belong to the same cadre were grouped according to their various departments: department A, department B, department C, and department D. Their mean and standard deviation are presented in Table 6.

	Department A	Department B	Department C	Department D
Mean Score	45.07	48.66	42.16	43.13
Standard Deviation	8.61	3.68	2.75	6.28

Table 6: Mean and Standard Deviation of Obtained Scores

Standard deviation computes how much an individual measurement should be expected to deviate from the mean on average. The smaller the standard deviation, the greater the consistency, predictability and quality of the system. It was discovered from Fig. 7 that department C has the smallest standard deviation showing that the proposed system works closely with the Standard of the institution.

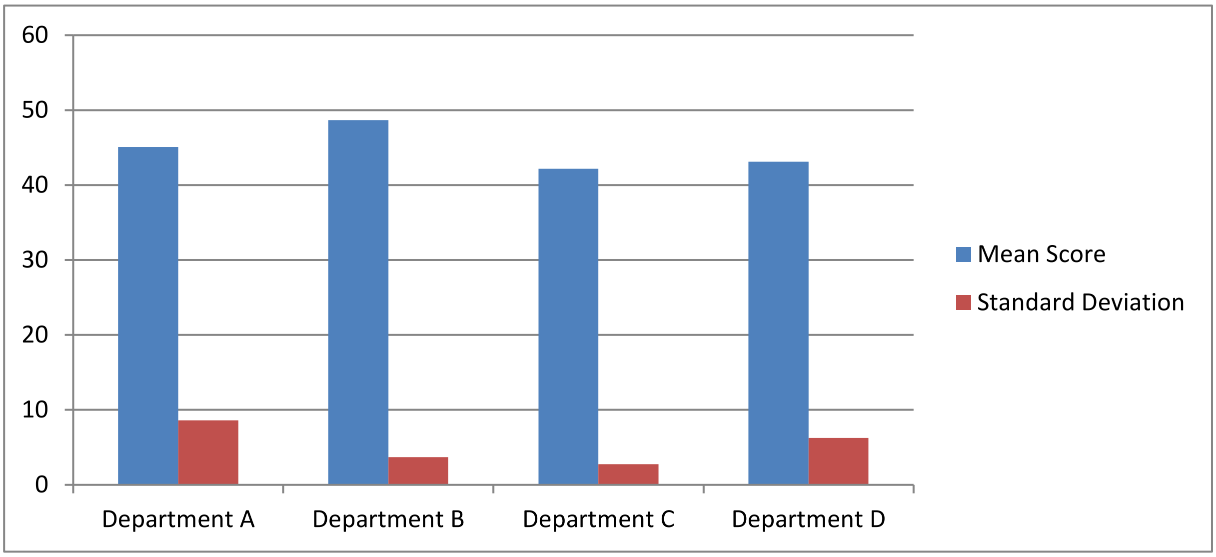

Figure 7. Standard Deviation of the Proposed System

When equation 14 was applied, It shows that the average score of human resource standard score per department is relatively the same as the FUTA standard score using actual value or approximate value except users who are not yet due for promotion to next cadre or users whose other conditions for promotion were not met. However, Table A2 (Appendix A2) and Fig. 8 show that the scores obtained by academic staff that used the system were above the two standards.

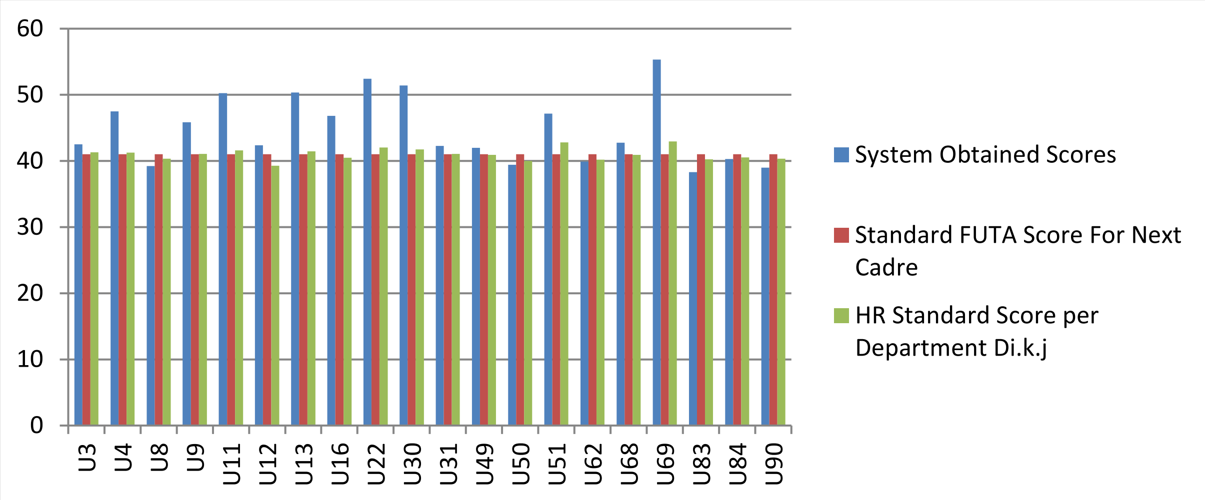

Figure 8. Obtained Score versus HR Standard Score per Department/Futa Standard Score

4.2.2 Proposed System Performance Prediction

The predictions of proposed system and their possibility scores for ten academic staff manually graded among the users were compared with the conventional scores manually giving. Table A3 (Appendix A3) and Fig. 9 depict the value of the system performance status that shows whether the performance of each academic staff is accurately predicted or not when compared with the manual score.

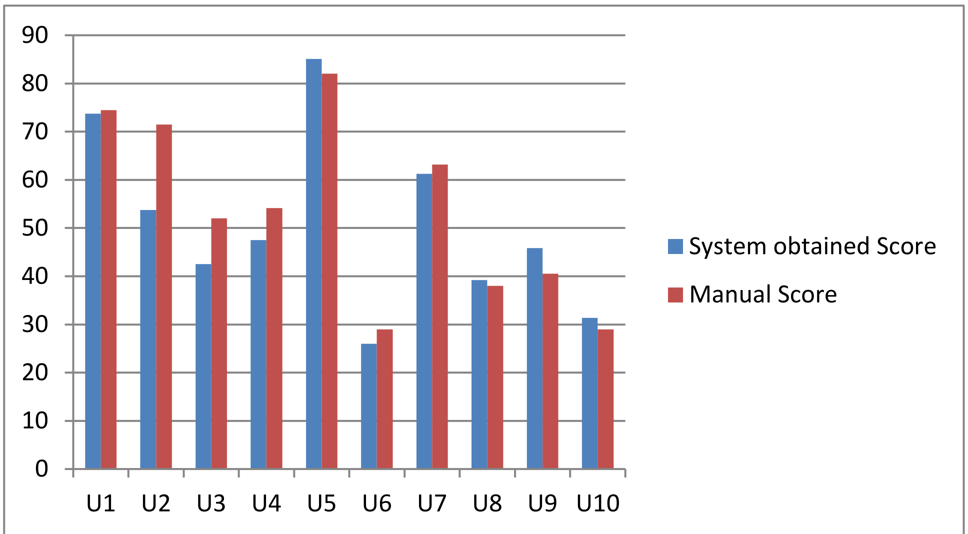

Figure 9. System Obtained Score versus Manual Scores

4.2.3 Precision Evaluation for the Proposed System

Precision is a measure that helps to evaluate the quality of an unordered set of retrieved items. Average precision (AP) measures the average of un-interpolated precision values at every rank where relevant items are found (Bestgen, 2015, Zhai et al.2015).

Let Uk represent the status of the prediction for the kth performance outcome such that

$$U_k = \begin{cases} 1(\text{if the kth outcome is Accurate} \\ 0(\text{if the kth outcome is inaccurate} \end{cases}$$

The average precision of the proposed system is computed as follows:

$$Precision = \frac{1}{n}\sum_{k=1}^{n} U_k \;\; for\ all\ U_k = 1 \quad (15)$$

$$Precision = \frac{Count\ of\ Accurate\ Predictions}{Total\ number\ of\ Predictions} = \frac{6}{10} = 0.6$$

While the average imprecision of the proposed system is computed as follows

$$Imprecision = \frac{Count\ of\ Inaccurate\ Predictions}{Total\ Number\ of\ Predictions} = \frac{4}{10} = 0.4$$

Also, from the result of the Precision measure, the proposed system has 0.6 probability of predicting accurately the score of an academic staff and 0.4 chances of predicting wrongly the score of an academic staff.

4.3 Comparison of Result with Related Works

Precision method was used by (Samuel and Omisoore, 2014) for the same cadre of academic staff; they got 0.78 accurate predictions and 0.22 inaccurate prediction of an academic staff appraisal. Table 7 shows a clear difference between the proposed system and (Samuel et al, 2014) system according to the categories of comparison between the two systems, the proposed system shows a better performance than Samuel et al (2014) system owing to the fact that the system used both comparative analysis as well as precision evaluation metrics.

Categories of Comparison	Samuel et al System	Proposed system
Accurate Prediction (%)	0.78	0.6
Category of Academic staff	One Cadre	All Cadre
Number of Users per time	One User	Simultaneous/multiple users
Number of system used	One system	Many Systems
System Requirements	Limited requirement	More hardware & Software Requirements
Dataset used	50	100

Table 7: Comparison of proposed System with Related work

5 Conclusions

This work presents a mathematical relation and rough set model to effectively evaluate academic staff of an institution for promotion. The system allows users to interact online and presents a faster system void of bias and sentiments for annual performance evaluation. Rough set theory was adopted to evaluate the criteria for promotion vis-à-vis qualifications, research and publications, teaching and professional duties, length of service and contribution to the university and nation. This work particularly proposes a model that could be generally acceptable for evaluating publications to eliminate the stress it takes manually, considering publication venue, number of authors and contribution of each. Experiments were carried out to evaluate the performance of the proposed system. The system obtained score was compared with the institution standard and it was found that the system scores were above standard; the average precision of the system shows 60% effectiveness using precision measurement.

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Appendix A1

	CRITERIA / CONDITION ATTRIBUTES							DECISION
Staff & Cadre (Y)	**A_1**	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**$A_8 = D$**
Y_1	7 – 21	≥0	≥0	≥0	≥0	1	**≥0**	D_1
	< 7	≥0	≥0	≥0	≥0	1	**≥0**	NQ
Y_2	22 – 27	≥0	≥0	≥0	1	2	**≥0**	D_2
	22 – 27	≥1	≥1	≥0	≥0	2	**≥0**	D_2
	< 22	≥0	≥0	≥0	≥0	2	**≥0**	NQ
	22 – 27	0	0	≥0	0	2	**≥0**	NQ
	22 – 27	0	≥1	≥0	0	2	**≥0**	NQ
	22 – 27	≥1	0	0	0	2	**≥0**	NQ
Y_3	28 - 40	≥2	≥2	≥0	1	3	**≥0**	D_3
	28 – 40	≥3	≥0	≥0	1	3	**≥0**	D_3
	28 – 40	≥4	≥0	≥0	≥0	3	**≥0**	D_3
	28 – 40	≥3	≥2	≥0	≥0	3	**≥0**	D_3
	< 28	≥0	≥0	≥0	≥0	3	**≥0**	NQ
	28 - 40	3	0	0	0	3	**≥0**	NQ
	28 - 40	2	1	0	≥0	3	**≥0**	NQ
	28 - 40	3	1	≥0	0	3	**≥0**	NQ
Y_4	41 – 51	≥8	≥0	≥2	1	4	**≥1**	D_4
	41 – 51	≥6	≥4	≥2	1	4	**≥1**	D_4
	< 41	≥6	≥0	≥0	1	4	**≥1**	NQ
	41 – 51	≥6	≥0	≥0	0	4	**≥1**	NQ
	41 – 51	≥8	≥0	≥0	0	4	**≥1**	NQ
	41 - 51	5	≥0	≥0	0	4	**≥1**	NQ
Y_5	52 – 60	≥13	≥0	≥4	1	5	**≥2**	D_5
	52 – 60	≥16	≥4	≥4	1	5	**≥2**	D_5
	< 52	≥13	≥0	≥4	1	5	**≥2**	NQ
	52 - 60	12	≥4	≥4	1	5	**≥2**	NQ
Y_6	61 – 100	≥20	≥0	≥6	1	6	**≥3**	D_6
	61 – 100	≥18	≥4	≥6	1	6	**≥3**	D_6
	< 61	≥18	≥4	≥6	1	6	**≥3**	NQ
	61 – 100	17	≥0	≥6	1	6	**≥3**	NQ

Table A1: Rough Set Information System for Evaluation of an Academic Staff

Appendix A2

Users (U)	System Obtained Scores	Standard FUTA Score For Next Cadre	HR Standard Score per Department $D_{i.k.j}$
U3	42.53	41	41.29
U4	47.50	41	41.28
U8	39.21	41	40.32
U9	45.84	41	41.09
U11	50.25	41	41.60
U12	42.35	41	39.29
U13	50.33	41	41.45
U16	46.81	41	40.49
U22	52.43	41	42.02
U30	51.39	41	41.74
U31	42.29	41	41.05
U49	42.00	41	40.94
U50	39.41	41	40.00
U51	47.17	41	42.82
U62	39.93	41	40.19
U68	42.74	41	40.94
U69	55.32	41	42.94
U83	38.30	41	40.23
U84	40.30	41	40.55
U90	39.00	41	40.34

Table A2: Obtained Score versus HR Standard Score per Department

Appendix A3

Users	System obtained Score	Manual Score	Difference in Score	System Performance Status
U1	73.74	74.48	0.74	1
U2	53.76	71.46	17.7	0
U3	42.53	52	9.47	0
U4	47.50	54.15	6.65	0
U5	85.05	82	3.05	1
U6	26	29	3	1
U7	61.26	63.18	1.92	1
U8	39.21	38	1.21	1
U9	45.84	40.5	5.34	0
U10	31.36	29	2.36	1

Table A3: System Performance Prediction of an Academic Staff

Note: A value of one (1) represents accurate prediction when the difference between the system obtained score and the manual score is plus or minus 3, while zero (0) represents inaccurate prediction when the difference between the system obtained score and manual score is not within plus or minus 3.

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