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MULTI-CRITERIA OPTIMIZATION FOR KNOWLEDGE EXTENSIONISTS IN INTERNAL KNOWLEDGE TRANSFER OF HIGHER EDUCATION IN NIGERIA

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ABSTRACT

The demand for high education in an environment of an insufficient number of experts requires efficient knowledge management. The introduction of knowledge extensionists in higher learning institutions remains relevant to bridge the gap created by this imbalance. In this work, we developed a new multi-objective mathematical model for optimizing the knowledge transfer capability of extensionists and knowledge management in higher learning institutions in Nigeria. The Model provides the information needed for a detailed analysis of the design trade-off between conflicting objectives that are most interesting to a decision-maker. The binary Integer MultiObjective Model is a suitable model for a population of potential solutions. The Model focused on practical factors for effective knowledge transfer. Several indices were considered, such as number of task types, number of clusters (groups), number of employees, etc., as the knowledge transfer (KT) assessment factors. Some parameters are adequate to recognize the KT potential in an employee, such as whether task type can be handled by an employee, whether the employee is interested in cooperating with another employee, used the minimum size of the cluster in terms of the number of employees. The concept of "interest to work with each other" is a novel aspect considered in the recommended algorithm. Therefore, for illustration, an intelligent algorithm based on matrix and clustering concepts to evaluate data collected via a questionnaire from Waziri Umaru Federal Polytechnic Birnin Kebbi, Nigeria was developed. The model is suitable for any given set of data to be applied elsewhere.

Keywords: Multi-Objective Mathematical Model; knowledge extensionists; Knowledge Transfer; the higher institution of learning

INTRODUCTION

The ever growing of data and technologies triggers knowledge as the transformation of data into helpful information.Today, people see the importance of learning and ways to acquire, recognize, capture, retrieve, use or measure, manage, and collaborate to transfer the knowledge without losing it (Maizatul and Chua, 2006). As a result of those, as mentioned earlier, the term Knowledge Management (KM) was created for this purpose. Knowledge management has been widely accepted and implemented in organizations, and knowledge is the most crucial resource of organizations (Alvesson and Karreman, 2001; Minu, 2003; Nahapiet and Ghoshal, 1998; Spender and Grant, 1996; Christian & Adrian, 2010). Manipulating knowledge, creation of knowledge storing of knowledge, sharing knowledge and application of it helps organizations gain a competitive advantage (Nonaka and Teece, 2000; Argote and Ingram, 2000).

Knowledge management being new, especially in higher institutions of learning. Recently, researchers have expanded studies of knowledge management into the domain of higher education. Knowledge management techniques and technologies approach in higher education is as vital as in the corporate sector. If effectively applied, it can lead to better decision-making capabilities, reduced product development cycle time (e.g., curriculum development and research), improved academic and administrative services, and lowered costs (Jillinda*et al.*, 2000).

High education in today's environment is subject to the same pressure as the marketplace. The increased demand for knowledge and increased competition have pushed high education institutions to think like a business. The educational markets are becoming global as high education institutions attempt to internationalize their curricula and offer high-quality programs to students regardless of location (Anand and Agrawal, 2003). They are also facing higher competition for a share of the student market, both local and international. However, in Nigeria, the situation is the same, where students compete for entry into high institutions, as observed by Victor (2007). "The demand for entry into Nigerian universities is usually very high and competitive. As of 2017, the total number of Nigerian universities, both privates and the public, was 152, of which 40 were federal government-owned, 44 were state government, and 68 were privately owned (Ayingor, 2017). Unfortunately, the number of applicants outweighs the number of available spaces" Afemikhe (2008).

According to Salim (1997), the general untidiness of this uncoordinated system of admissions and the attendant problems had assumed new proportions with new universities, polytechnics, and education colleges. In this new Millennium, knowledge is power, and more knowledge is within individuals more than in records (Anand, and Agrawal, 2003). Moreover, high institutions have to adjust themselves and develop strategies to respond rapidly to the changes in technologies and increasing demands of stakeholders.

An institution-wide application of knowledge management can lead to a drastic exponential improvement in sharing knowledge (Jillinda*et al.*, 2000). In the context of educational institutions, sharing knowledge is paramount to the existence of an educational institution (Liao, 2004). Knowledge transfer is the primary key to effective teaching and learning in high education. It contributes to guiding and improving students' professional development (Teresa *et al.*, 2008).

Feng *et al.* (2009) made the first attempt to introduce and acknowledge the unique role of extensionists in the knowledge transfer process in expert system application to

Agriculture. It implies that the Extensionist in knowledge transfer is a recent development and presents an exciting direction for further research in other areas of knowledge transfer as in the case of higher education in Nigeria since the intermediary role of the extensionists exists as the demand for the intensive involvement of experts in KT increases in higher institutions of learning, coupled with the fact that we have an insufficient number of such experts in the higher education sector, the role of the Knowledge extensionists in many of our higher institutions of learning remain relevant to bridge the gap created by this imbalance.

A review of existing knowledge management models by Haslinda&Sarinah (2009) has shown a broad spectrum of perspectives. From the definite view, Knowledge management is categorized into discrete elements, as established in Boisot's (1987) model. Kogut & Zander's (1992) KM model focused on the strategic importance of knowledge as a source of competitive advantage. Hedlund and Nonaka, (1993) Schematic KM model and Nonaka and Takeuchi (1995) conceptual model to the more complicated and complex perspective of knowledge that is mechanistic and socially constructed orientation as indicated by Skandia intellectual capital model of knowledge management(Chase, 1997 &Roos and Roos, 1997). However, this approach can result in attempts to fit objective measures to subjective elements. Hence, this mechanical approach to measurement is more consistent with Nonaka's process of externalization and combination.

Moreover, these knowledge management conceptual models have referred to:

i. The process of managing the flows knowledge
ii. Categorization models are mechanistic.
iii. The intellectual capital model assumed that intellectual capital is a vital asset in an organization and should be managed efficiently for a firm's success.
iv. Demerest's model (Adam &Creedy, 2000) connected with organizations' social and learning processes.
v. Frid's (2003) model suggests that knowledge should be managed systematically and emphasized at all knowledge management process levels.
vi. Stankosky and Baldanza's (2001) knowledge management framework emphasized that leadership, organization structure, technology infrastructure, and learning are essential foundations for knowledge management in an organization.

Indeed, these perspectives have indicated that knowledge management models have evolved. Musa *et al.* (2014a) developed a conceptual model for knowledge transfer in higher education in Nigeria incorporating knowledge extensionists, thereby improving the already existing knowledge management in the higher education model developed by Ko*et al.* (2005). Even though many conceptual knowledge management models have evolved from time to time, the conceptual models usually translate managerial activities and guide administrative efforts in managing knowledge in the organizations. All the models described are abstract, but they can be mathematically to incorporate the knowledge transfer process in higher learning institutions. This work is motivated by the conceptual nature of the model. Therefore, a mathematical model, a Multi-objective optimization model, was developed. Multi-objective optimization can deal with problems that involve conflicting objectives, such as knowledge transfer through extensionists. It is also an area of multiple criteria decision-making that concerns issues involving more than one objective function to be optimized simultaneously. To the best of our knowledge and research, this is the first time a multi-objective optimization model has developed for the area of knowledge transfer that involves extensionists. Ben*et al*. (2019), proposes a multi-criteria-based approachfor evaluating and model for languages (process oriented and knowledge oriented) for therepresentation of Sensitive Business Process SBPs, taking into account their specific modeling requirements. The different modeling languages were assessed according to the ontological completeness of SBP, they were evaluated according to several key requirement indicators (e.g., understandability, expressibility, complexity, level of adoption, tools availability and extendibility). Boniface *et al.*(2020), applied in utilization of information technology enable system in agricultural by agricultural extensionists in Kerala, the study revealed that knowledge of agricultural extensionists on web browsing and agricultural portals was comparatively higher.

The model aims to bridge the gap identified in the literature of the non-availability of generic mathematical models to study knowledge transfer activities. It provides a qualitative basis for assessing the number of extensionists required and identifying their adequate numbers that can move from one cluster to another to accomplish a task together at every collection (college) of higher learning organizations.

METHODOLOGY

The data on extensionists were collected from Waziri Umar Federal Polytechnic Birnin Kebbi, Nigeria, and analyzed with the aid of WinQSB software using the knowledge transfer parameters which include: processing tasks by employees, interest in cooperating to accomplish a task, the minimum size of the cluster in terms of employees and the number of tasks, a minimum size of the cluster in terms of employees and the maximum number of tasks that employees can do. As a result, a mathematical model to maximize knowledge transfer capability in a higher institution of learning for knowledge extensionists was developed. The proposed mathematical model focused on effective factors for knowledge transfer. To conceptualize knowledge, transfer in a higher institution of learning, an intelligent algorithm based on matrix and clustering concepts was used. The steps of the proposed algorithm are given below:

Step I: An initial study was worked out on the structures of the higher institution's academic staff and considering a threshold (the academic study grade) some potentially appropriate staff were selected for the KT process (only those that fall within the cadre of extensionists were considered). Here, the identified staff falling into the category of extensionists were grouped and made to work on academic tasks to have an idea of how they perform on different academic tasks.

Step II: After choosing the academic staff, KT groups were organized to work on KT problems in a creative manner. To do that, the KT tasks were determined. The KT tasks for staff were collected in a 2-dimensional matrix. This matrix was completed by 0 or 1 values, where if an employee (E_i) has experienced for a task (T_j) then the numerical value R_{ij} for i=1,..,m and j=1,..,n is 1 and 0 otherwise, where m is the number of employees and n, the number of tasks. A taskemployee matrix is configured in Table1.

Table1: Task-Employee Matrix

Task (T) / Employee (E)	T_1	T_2	…	T_n
E_1				
E_2				
.				
.	→	→	$R_{ij} \in \{0,1\}$	
.				
E_m				

It was assumed that the available employees deliver their favorite KT tasks' vector by filling a given questionnaire. Aggregating the responses from the questionnaires provide the tasks' vector of all employees. This way, a matrix containing the available employees and their favorite KT tasks was constituted.

Step III: Another effective parameter essential for the team organization is the interest to work harmoniously with each other. To consider interest, the former employee-task matrix is assumed and a third dimension of "interest" is added. Each employee expresses his opinion about the "interest" to work with one another employees with 1 (if interested) and 0 (otherwise). Integrating all employees' opinions, an employee-employee matrix is constructed and shown in Table2.

Note that, $P_{ij}$is 1 if both employees have the interest to work with each other.

Step IV: Here, matrix F is configured in 3-dimensional. The values of F_{ijk} are 1 and 0. The 3-dimensional matrix F is depicted in Figure 1. Now, the clustering based on matrix F was performed. The arrangement was performed to organize KT teams using mathematical programming. This is achieved if the two earlier matrices are compatible for multiplication with one another.

Step V: After clustering, brainstorming sessions of teams causes KT subject generation. At this stage, teams may need academic knowledge rather than their organizational knowledge. This way, College members helped teams in conducting KT on a specified subject. During the KT process, external information from other team members and even other members out of the team as required

Table 2: Employee-Employee Matrix

Employee (E) / Employee (E)	E_1	E_2	…	E_m
E_1				
E_2				
.				
.	→	→	$P_{ij} \in \{0,1\}$	
.				
E_m				

.

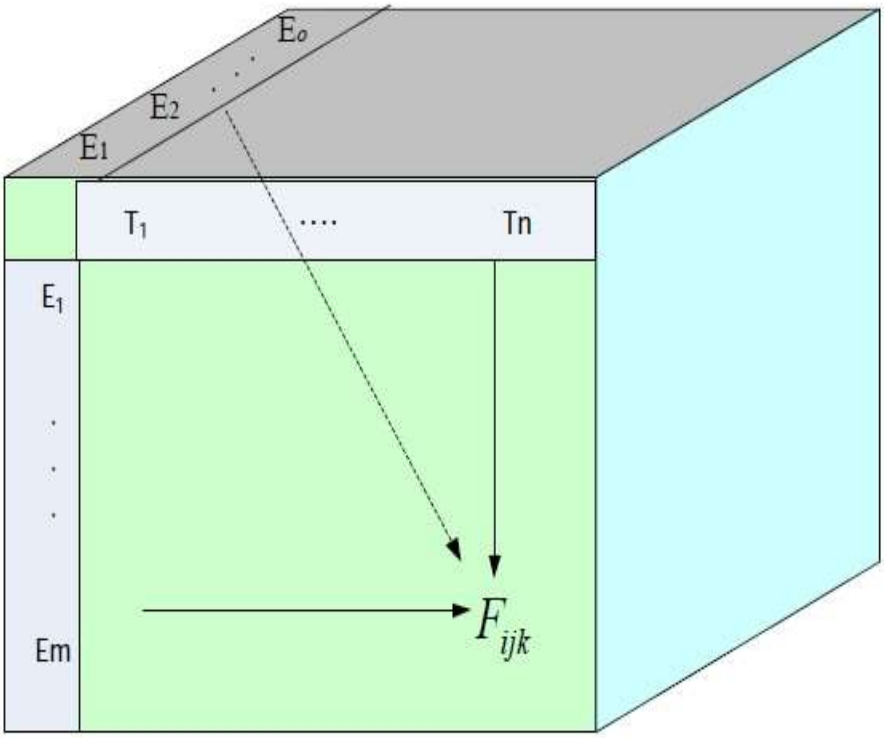

Figure 1: The 3-dimensional matrix depicting employee-task-employee

After identifying the KT tasks for staff which will be collected in a 2-dimentional matrix, the matrix will be completed by 0 or 1 values, where if employee (E_i) has experiences for task (T_j) then the numerical value R_{ij} for i=1,.., *m* and j=1,.., *n* is 1 and 0, otherwise where *m* is the number of employees and *n*, the number of tasks. This matrix is called the task –employee matrix detailing the type of tasks each of the employees can handle. A task-employee matrix is configured in Table 1.

Next the employee-employee matrix will also be configured to determine the willingness of each of the employees to cooperate and work with each other to solve a particular task. This will also be collected as a 2-dimensional matrix. Now, each employee expresses his opinion about the "interest" to work with other employees with 1 (if interested) and 0 (otherwise). Note that, P_{ij} is 1 if both employees have interest to work with each other. Integrating all employees' opinions, an employee-employee matrix is configured and shown in Table 2.

Now having configured the task-employee and employee-employee matrices as described above, the 3- dimensional matrix is now configured by combining the 2- dimensional matrices of task-employee and employee-employee matrices to obtain the 3- dimensional matrix in figure 1, resulting in values for F_{ijk} which will also be completed by 0, 1 similar to the two matrices combined to obtain these results. This means F_{ijk} values are directly determined from R_{ij} and P_{ij} from the binary values of task-employee and employer-employee matrices respectively. However the 3- dimensional matrix will only be possible to configure when the two earlier matrices are compatible for multiplication with one another.

Once the 3-dimmensional matrix is obtained, clustering, brain storming sessions of teams will cause KT subject generation. In this stage, teams may need academic knowledge rather than their own organizational knowledge. This way, College members will help teams in conducting KT on a specified subject. During the KT process, external information from other team members and even members out of the team were required.

THE MATHEMATICAL MODEL

Based on the methodology highlighted above an integer multi-objective mathematical model of the problem is as follows:

$$Max\ Z = \sum_{k=1}^{K}\sum_{t=1}^{T}\sum_{e=1}^{E}\pi N_{tek} \tag{1}$$

$$Max\ Z = \sum_{k=1}^{K}\sum_{t=1}^{T}\sum_{e=1}^{E}\theta N_{tek}\left(1-Y\right)_{ek} \tag{2}$$

$Subject\, to:$

$$\sum_{k=1}^{K} X_{tk} = 1 \qquad \forall t \tag{3}$$

$$\sum_{k=1}^{K} Y_{ek} \geq 1 \qquad \forall e \tag{4}$$

$$\sum_{k=1}^{K} X_{tk} \geq LT \qquad \forall k \tag{5}$$

$$\sum_{e=1}^{E} y_{ek} \geq LW \qquad \forall k \tag{6}$$

$$\sum_{e=1}^{E} N_{tek} \geq X_{tk} \qquad \forall t,k \tag{7}$$

$$\sum_{e=1}^{E} N_{tek} \leq AX_{tk} \qquad \forall t,k \tag{8}$$

$$N_{tek} \leq a_{te} \qquad \forall t,e,k \tag{9}$$

$$N_{tek}N_{te'k}\left(1-b_{ee'}\right)=0 \qquad \forall t,e,e',k;\ e \neq e' \tag{10}$$

$$\sum_{k=1}^{K}\sum_{t=1}^{T} N_{tek} \leq LE \qquad \forall e, \tag{11}$$

$$X_{tk},\ Y_{ek},\ N_{tek} \in \{0,1\} \qquad \forall t,e,k, \tag{12}$$

Model Indices

$t: Index\ for\ different\ Task\ (t=1,2,\ldots T)$

$k: Index\ for\ Different\ Clusters\ (k=1,2,\ldots K)$

$e: Index\ for\ Different\ Employees\ (e=1,2,\ldots E)$

$d: Index\ for\ Departments\ (d=1,2,\ldots D)$

$\pi: Binary\ set\ of\ Employee-Employee\ Matrix\ in\ the\ 3-\dim mensional\ set$

$\theta: Binary\ set\ of\ Task-Employee\ Matrix\ in\ the\ 3-\dim mensional\ set$

Input Parameters

$a_{te} = 1\ if\ a\ given\ task\ type\ t\ can\ be\ processed\ by\ employee\ e,\ otherwise\ 0.$

$b_{ee'} = 1\ if\ employee\ e\ is\ \text{int}\, erested\ by\ employee\ e,\ otherwise\ 0.$

$LT = Minimum\ number\ of\ each\ cluster\ in\ terms\ of\ the\ available\ task\ types.$

$LW = Minimum\ number\ of\ each\ cluster\ in\ terms\ of\ the\ available\ employee.$

$LE = Minimum\ number\ task\ which\ an\ employee\ can\ do.$

$A = An\ arbitrary\ big\ positive\ number.$

Decision Variables

$X_{tk} = 1\ if\ task\ type\ t\ is\ assigned\ to\ cluster\ k,\ otherwise\ 0$

$Y_{ek} = 1\ if\ employee\ e\ is\ assigned\ to\ cluster\ k,\ otherwise\ 0$

$N_{tek} = 1\ if\ task\ type\ t\ is\ processed\ with\ employeee\ in\ cluster\ k,\ otherwise\ 0$

RESULTS AND DISCUSSION

Knowledge will remain a foundation of a higher institution's competitive advantage in years to come. Overall, this study intended to enhance the understanding of how knowledge extensionists enables a higher institution of learning to effectively manage its knowledge assets to improve job performance of knowledge workers over time and how to improve their utilization and use within an institution of learning. The adequate utilization of the extensionists in performing various tasks in knowledge transfer activities from different colleges are affected by various group and individual characteristics (e.g., social networks and physical documents available, geographical distance from one college to another, usage patterns, usage by other employees in the same high institution as internal competitors), external environments (high institution's dynamics), and technology characteristics (e.g., access to other types of knowledge paths) may results in how school managers can improve and promote the usage of their extensionists depending on the characteristics of individuals and their tasks.

Model Implementation

The model was implemented for WaziriUmaru Federal Polytechnic Birnin Kebbi. A structured questionnaire was used to gather the necessary data for the model. Academic staff in the Polytechnic includes Lecturers employed with qualifications below second class lower degree, Instructors and Technologists (extensionists) were targeted. The various components of the model were considered as follows:

Tasks

The following tasks are considered for the developed model:

i. Lecturing
ii. Laboratory Practical
iii. Workshop Instruction
iv. Field Work

Clusters

There were four colleges in the Polytechnic and these were used as readymade clusters with a view to grouping the extensionists for task processing. Several departments within the cluster are shown in Table 3 below.

Table 3: Number of Departments within Cluster

S/No.	Cluster	No. of Department
1.	College of Administration	6
2.	College of Engineering	5
3.	College of Environmental Studies	6
4	College of Science and Technology	11

Employees

The employees (extensionists) were divided into three categories based on the nature of employment:

i. Lecturers with qualification below second class lower degree
ii. Instructors
iii. Technologists

Structured questionnaires were administered to the Extensionists in each of the four clusters for the identified tasks to generate data for running the model.

For the model implementation we considered four clusters (K=4), four tasks (T=4), twenty-eight departments, and eighty-six employees (E=86) as shown in Table 4 below:

Table 4: The Number of Employees, Departments, and tasks available within the Clusters

S/No.	Cluster K	No. of Employees e	No. of Departments d	No. of tasks t
1.	College of Administration	5	6	4
2.	College of Engineering	52	5	4
3.	College of Environmental Studies	17	11	4
4.	College of Science and Technology	12	6	4

First, the model was solved for the entire institution of WaziriUmaru Federal Polytechnic Birnin Kebbi and then solved for the various Sub-cluster (for k=d). The aim is to maximize the total number of extensionists that will team up and cooperate with one another to perform the same task at every point in time. Also to minimize the movement of extensionists within and outside the clusters to perform available tasks at hand. The following results were obtained and shown in Table 5 below.

Table 5: The Minimum and Maximum allocation of Extensionists across the Clusters Using Proposed Model

Cluster	No. of Extensionists	Maximum No. of Extensionists	Minimum No. of Extensionists
College of Administration	5	3	1
College of Environmental Studies	12	7	5
College of Engineering	52	34	21
College of Science and Technology	17	9	6
All colleges	**86**	**45**	**32**

In Table 5 it is observed that in the college of Administration (first cluster) the maximum number of extensionists in the college of Administration that can cooperate to work on the same task at every point in time is 3 out of the five available. The minimum number of extensionists that can effectively move within the cluster (the six Departments) to perform a task is 1 out of the five considered for this study. For the College of Environmental Studies (second cluster) the maximum number of extensionists in the college that can cooperate to work on the same task at every point in time is 7 out of the 12 available. The minimum number of extensionists that can effectively move within the cluster (the six departments) in the college to handle tasks is 5 out of the 12 considered. In the College of Engineering (third cluster) the maximum number of extensionists that can cooperate to work on the same task at every point in time is 34 out of the 52 available, while the minimum number of employees that can effectively move within the cluster (the five departments) in the college is 21 out of the 52 available. Similarly in the College of Science and Technology (4th cluster), the maximum number of extensionists in the college that can cooperate to work on the same task at every point in time is 9 out of the 17 available. It was also revealed that the minimum number of employees that can effectively move within the cluster (the eleven departments) in the college is 6 out of the 17 considered. In all the colleges the number of available extensionists is 86 out of 45 who can cooperate to work on the same task at every point and 13 can be effectively moved with the institution.

CONCLUSION

In this study multi-objective mathematical Optimization model to evaluate knowledge transfer capability of knowledge extensionists within the context of knowledge management in higher institution of learning was proposed. Since the simplification and effective transfer of knowledge in any organization seems to be necessary, in this research a mathematical model to maximize the number of employees willing to work together to accomplish tasks and minimize the movement of employees within and across clusters to accomplish tasks was presented. Computational results in this study confirmed the effectiveness of the model by reporting the effective number of extensionists required to handle tasks in different colleges of a high institution of learning that will be needed to effectively handle tasks in effective transfer of knowledge within the colleges and across the institution as a whole. The model demonstrate the ability of using multi-criteria optimization in the field of knowledge management which is rear in all the literatures reviewed. The model can be applied to any real-life data set from any institution of higher learning as illustrated in this paper.

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