THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Performance Evaluation of the Application of Terotechnology in the University of Benin, Nigeria, Enterprise Table Water Factory, Using Cronbach Alpha (α) Model

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Abstract:
Terotechnology is an observational science that integrates technological and managerial skills essentially for the socio-economic development of an industry, it is employed in this paper using statistical study to apply mathematical models such as the Cronbach alpha in analyzing data for performance evaluation of a table water factory gathered from administered questionnaires in a five Likert scale in order to evaluate its practices in the factory to help boost the productivity of the University of Benin Enterprises table water factory. The goal of this study is to reduce poor maintenance practices. Primary data were collected from the factory workers and utilized in computing the Cronbach Alpha in order to evaluate internal consistency collected data. From the index of association, α ≥ 0.9 was considered excellent and the percentage of respondents that strongly agreed on the practice of terotechnology was high at 265 out of 500 respondents with 53% response with a value of Cronbach Alpha recorded at 0.9598, indicating that the questions were internally consistent. Therefore, 85% of the workforce supported the implementation and the practice of Terotechnology in the table water factory in order to improve the day to day running of the table water factory.

Keywords: *Terotechnology, planning, records, operations, table water factory, Cronbach Alpha model*

1. Introduction

The performance of a physical asset during the in-service phase of its life-cycle is highly dependent on the maintenance and operation of the unit (Hodkiewicz *et al.*, 2006). Since the 1990s, it has been argued that the field of asset management requires an interdisciplinary approach in order to ensure that an appropriate mix of skills can be brought to bear on resolving the vexed issue of asset management. The new orientation has been on developing a range of strategic responses to safeguard the large public and private investments in assets (Arnadi-Echendu *et al.*, 2007). The practice of Terotechnology is concerned with the specification and design for reliability and maintainability of factory, machinery equipment, building and structure with their installation, commissioning, maintenance, modification and replacement, and with feedback of information, performance and cost (Hew gill and Parkes, 1979). The word terotechnology was developed in the United Kingdom in the early 1970s in order to solve problem of maintenance of plants and structure. It is derived for the Greek root word 'tero', or 'I care', that is now used with the term 'technology' to refer to the study of the cost associated with an asset throughout its life cycle-from acquisition to disposal. The University of Benin (UNIBEN) table water plant can successfully apply the concept of terotechnology by balancing all factors of the concept. It will require a proper understanding of management science such as accounting in the area of finance, budget and cost control and general knowledge of engineering that will deal with areas such as records, design, specification, maintenance, and areas such as staffing (recruitments, employment and training). Other areas are operations, installation, stocking, repairs and commissioning. With the above knowledge coming to play interactively, there will be an effective feedback of information that will help to improve the system, efficient, effective and competent handling maintenance problems and an achievement of corporate objectives with an effective control system having good communication and appraisal.

Terotechnology practices in the table water factory: Terotechnology is an applied science that helps to maintain assets such as the thirty (30) Dingli Automated machines used for water production in UNIBEN table water factory. The elements of terotechnology practiced in the table water factory include: Planning. Design/specifications, Records, Inspection, Operations (recruitments, training and job enhancement), Installation, Commissioning, Inventory/stocking (spare parts management and life cycle of assets). The Factory Manager's position is the nerve Centre from where all activities will be brought together. He obtains and analyses information from all other personnel associated with Acquiring assets**,** caring for assets and maintaining physical assets. There should be a very reliable network of information system in the table water factory.

- Planning: Proper planning is done by using shifts to run the day to day activates of the factory. There is daily maintenance of assets in the table water factory and there is a proper plan ground ensuring that employees stand on maintenance practices laid down for the factory.

- Records: Records are kept in the record section and all records pertaining to maintenance of equipment , machine utilization (number of hours the machine works), time involved, labor involved, budget, training and Staffing, inspection, sales, purchases and supplies are kept, documented and computerized in the University of Benin (UNIBEN) table water factory.
- Stocking: Proper inventory is carried out. The stores are stocked with spare parts and materials for production on a day to day basis.
- Inspection: Routine inspection is done in the factory and all assets are on a daily basis inspected, maintained and feed- back of information on inspection documented on software and this enhances the maintenance practices of the factory.
- Operations: Recruitments are done as at when due as management staff are recruited to their right areas of specifications. Training of staff is not done in the factory due to low awareness. All other elements of terotechnology were practiced in the University of Benin (UNIBEN) enterprises table water factory, Benin City, Edo State.

1.1. Gaps Covered in This Study

In Nigerian industries, maintenance is not given a high priority and hence factories are often under-utilized and run at high costs (Eti *et al.*, 2006). Organization and implementation of maintenance strategy in use so far in the country has yielded little positive results with the resultant that Nigerians are classified as part of 'poor maintenance culture' for engineering infrastructures (Olusanjo, 2006). When maintenance is relegated to the background in a production/industrial setting such as the University of Benin (UNIBEN) Table water, unreliability of equipment arises. Some of which are equipment failure, frequent overhaul of equipment and component reliability all of which reduces assets life span, maximize production loss resulting from breakdown or sudden failures and above all downtime will be increased. The application of terotechnology approach is to plan, develop a good maintenance engineering practice and improve the life span of assets in UNIBEN Table water factory. Applying the tools of terotechnology in conjunction with planned maintenance to extend the life span of physical assets, questionnaires were administered with questions relevant to the effects of planned maintenance and terotechnology and then using Cronbach Alpha (α) to measure the association between the respondents.

2. Research Methodology

The methodology used in carrying out the study comprised of: Research population, Sampling techniques, Method of data collection, Methods of data analysis and Theoretical brief on method of data analysis. The Cronbach Alpha (α) is the statistical test used for data analysis in this study.

3. Research Population

The research population is the university of Benin (UNIBEN) Enterprises, table water factory located at the University of Benin, Benin City, Edo State, Nigeria. The research population comprised of factory employees with age distribution of 20-30 years, 31-40 years, 41-50 years and 50 years and above.

4. Sampling Techniques

The research methodology conducted under the present study is the combination of primary and secondary data collected through questionnaires from selected 25 respondents to answer 20 questions. The present research study is empirical in nature, trading different multi-variant concluding observations relating to the various practices of Terotechnology and value-added services to the table water factory. The purpose of this research is to calculate Cronbach Alpha reliability co-efficient for standard of terotechnology practices in University of Benin (UNIBEN) Enterprise Table Water Factory. Typically, the 25 respondents were instructed to select one of five responses: strongly agree, agree, undecided (neither agree nor disagree), disagree and strongly disagree. The specific responses to the items are combined so that individuals with most favorable attitude will have the highest scores while individuals with the unfavorable attitudes will have the lowest scores. The scale is named after its inventor, psychologist Rensis Likert. The quality control officer tests the water for neutrality using a pH scale. The factory produces water having a pH of 7.2 which is neutral, safe for human consumption and this has been the practice for twenty-one years.

5. Method of Data Collection

Data was collected from the employees in the University of Benin (UNIBEN) Enterprise Table Water Factory through personal interviews and extracts from the record section of the table water factory. The data collected are on terotechnology, its elements as well as its acceptance in the table water factory in order to boost productivity.

6. Method of Data Analysis

After the questionnaire is completed, each item may be analyzed separately or in some item, responses may be summed up to create a score for a group of items. Hence, Likert scales are often called summative. The five-level Likert scale was employed in this analysis. Likert scales are arbitrary and the value assigned to a Likert item has no unique mathematical property either in terms of measure, theory or scale. The model employed is the Cronbach's alpha (α) Model.

7. Cronbach's Alpha Model

Cronbach Alpha (α) is defined as

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma_{y_i}^2}{\sigma^2 x}\right)$$

Where k is number of questions (k-items), $\sigma^2 x =$ variance of the observed total test scores, $\sigma^2 y_i =$ variance of component *i* for the current sample of respondents. Alternatively, the Cronbach Alpha can also be defined as

$\alpha = \frac{K\bar{C}}{\bar{V}+(K-1)\bar{C}}$ Where α = Cronbach Alpha, K = number of items/questions.

$\bar{C}$ = the average of all co-variances between the questions across the current sample of persons (that is, without including the variances of each components). Theoretically, Alpha (α) varies from zero (0) to one (1). It is the ratio of two variances. Empirically, however, it can take on any value less than or equal to 1. Higher values of Alpha are more desirable. Some professionals as a rule of thumb, require a reliability of 0.70 or higher (obtained on a substantial sample) before they will use an instrument (Cortina, 1993). This has resulted in a wide variance of test reliability. In the case of psychometric tests, most fall within the range of 0.75 to 0.83 with at least one claiming a Cronbach Alpha above 0.90 (Nunnally, 1978).

7.1. NInternal Consistency

Cronbach alpha will generally increase as the inter correlations among test items increase, and this is known as an internal consistency estimate of reliability of test scores. A commonly accepted rule of thumb for describing internal consistency using Cronbach Alpha is as follows, however, a greater number of items in the test can artificially inflate the value of Alpha and so this rule of thumb should be used with caution. Cronbach Alpha internal consistency (α) ≥ 0.9

Excellent, 0.8 ≤ (α) Good, 0.7 ≤ (α) Acceptable, 0.6 ≤ (α) Questionable, 0.5 ≤ (α) < 0.6 Poor, (α) < 0.5 Unacceptable (George and Mallery, 2003). Cronbach Alpha (α) is one of the most widely used measures of internal consistency. Items that are internally consistent can be seen as raters that agree about the 'true' value of the construct (subject matter) associated with the items/questions in the research work. In that case, Cronbach Alpha could be seen as an agreement coefficient or a measure of reliability.

7.2. Length of Test

The test length measured by the number of items affects the magnitude of Cronbach Alpha that is, Alpha increases as the number of items (k) increase. Consequently, a good test must have an adequate number of items in order to achieve a reasonable internal consistency as evaluated with Cronbach Alpha in this research. K = number of items/questions = 25, s_i^2 = variance associated with item *i.*, S_T^2 = variance associated with the total (or sum) of all K item score. Hence, we have 25 item variances from S_1^2 to S_{25}^2. Each of the 25 item variances may be calculated using the data in each item's column. Then the total variances S_T^2 may be calculated using data in the total column.

Respondents	Questions/ Items																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total
1	4	4	4	5	5	4	4	5	5	5	4	5	4	4	4	1	5	4	4	4	4	4	4	4	4	104
2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	3	4	4	4	4	4	98
3	3	4	4	5	4	4	4	5	4	4	4	5	4	4	4	5	5	5	5	5	5	5	5	5	5	112
4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	125
5	3	5	5	5	5	5	5	5	5	5	5	5	1	5	5	5	5	5	5	5	5	5	5	5	5	119
nt s	Questions/ Items																									

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total
6	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	101
7	4	4	4	5	5	4	4	5	5	5	4	5	4	4	5	5	4	4	4	4	4	4	4	4	5	109
8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	125
9	4	4	4	4	4	4	4	5	5	5	5	5	5	4	5	4	4	4	4	4	4	4	4	4	4	107
10	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	117
11	4	4	4	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4	4	4	4	4	4	115
12	3	4	4	4	4	3	4	3	4	4	4	4	2	4	4	4	4	4	4	4	4	3	4	4	4	94
13	4	4	4	3	4	3	4	3	4	5	4	4	3	4	3	4	5	4	3	4	4	4	4	4	4	96
14	3	4	4	4	4	3	4	3	5	4	3	4	4	2	4	4	3	5	4	1	4	5	4	3	3	91
15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	117
16	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	125
17	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	125
18	3	4	4	4	4	3	4	3	4	4	4	4	2	4	4	4	4	4	4	4	4	3	4	4	4	94
19	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	125
20	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	125
Sum	83	89	89	92	92	86	90	90	94	94	89	94	82	88	90	89	92	90	88	84	89	87	88	87	88	2224

Table 1: Table of Total Variances S_T^2 Calculated Using Data Collected

Cronbach's Alpha (α) is defined as

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma^2_{y_i}}{\sigma^2 x}\right)$$

k is number of questions (k-items)

$\sigma^2 x =$ variance of the observed total test scores, $\sigma^2 y_i =$ variance of component *i* for the current sample of respondents.

Questions/Items(K=25)	Variance for All the K Items ($\sigma^2 y_i$)	Variance Associated with Total Score ($\sigma^2 x$)
1	0.660526	
2	0.260526	
3	0.260526	
4	0.239474	
5	0.252632	
6	0.642105	
7	0.263158	
8	0.684211	
9	0.221053	
10	0.221053	
11	0.365789	
12	0.221053	
13	1.463158	
14	0.568421	
15	0.473684	
16	0.892105	
17	0.357895	
18	0.263158	
19	0.344737	
20	0.905263	
21	0.252632	
22	0.45	
23	0.252632	
24	0.905263	
25	0.357895	
SUM	11.77895	S_T^2 = 149.79

Table 2: Table of Variances for All the K Items ($\sigma^2 y_i$)

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \sigma^2_{y_i}}{\sigma^2 x}\right) = \frac{25}{25-1}\left(1 - \frac{11.779}{149.79}\right)$$

$$\alpha = 1.0417\,(1 - 0.0786)$$

$$\alpha = 1.0417 \times 0.9214$$

$$\alpha = 0.9598$$

From the index of association, α ≥ 0.9 is considered excellent. Therefore, the value of Cronbach Alpha ($\alpha = 0.9598$) indicates that the questions were internally consistent.

Respondent	Strongly disagree	Disagree	Undecided	Agree	Strongly agree	Total number of questions/items
	1	**2**	**3**	**4**	**5**	
1	1	-	-	17	7	25

2	-	-	2	23		25
3	-	-	1	11	13	25
4	-	-	-		25	25
5	1	-	1		23	25
6	-	-	-	24	1	25
7	-	-	-	16	9	25
8	-	-	-		25	25
9	-	-	-	18	7	25
10	-	-	-	8	17	25
11	-	-	-	10	15	25
12	-	-	4	20	1	25
13	-	-	6	17	2	25
14	1	1	7	13	3	25
15	-	-	-	8	17	25
16	-	-	-		25	25
17	-	-	-		25	25
18	-	1	4	20		25
19	-	-	-		25	25
20	-	-	-		25	25
Summation	3	2	25	205	265	500

Table 3: Performance Evaluation of the Practice of Terotechnology in the University of Benin (UNIBEN) Table Water Factory Using the 5-Point Likert Scale for Evaluation

Assessing the effectiveness of the respondents from their responses to 25 questions on a five-point Likert scale
Where 1 = Strongly disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly agree
From the table above, respondents that agreed on the subject matter are on a high scale.
Strongly agree 265, Agree 205, Undecided 25, Disagree 2, strongly disagree 3.
The percentage of respondents that strongly agree on the practice of terotechnology is high.

Calculation for the percentage (%) of responses on the practice of terotechnology in the University of Benin (UNIBEN) Enterprises table water factory.
Total number of 'Strongly agree' responses = 265
Total number of question/items = 500

$$\% = \frac{265}{500}\ x \frac{100}{1} = 53\%$$

Total number of 'Agree' responses = 205
Total number of question/items = 500

$$\% = \frac{205}{500}\ x \frac{100}{1} = 41\%$$

Total number of 'Undecided' responses = 25

$$\% = \frac{25}{500}\ x \frac{100}{1} = 5\%$$

5% of the total respondents were undecided on the subject matter.
Total number of 'Disagree' responses = 2

$$\% = \frac{2}{500}\ x \frac{100}{1} = 0.4\%$$

Total number of 'Stronglydisagree' responses= 3

$$\% = \frac{3}{500}\ x \frac{100}{1} = 0.6\%$$

7.3. Summary

The responses to the 25 questions in the questionnaire of a five-point Likert scale all had different percentages.

5-Point Likert Scale	**Percentages (%)**
5 = Strongly agree	53%
4 = Agree	41%
3 = Undecided	5%

2 = Disagree	0.4%
1 = Strongly disagree	0.6%

Table 4: Table of Percentage of Respondents Using Likert Scale

The percentage of respondents that strongly agreed on the practice of terotechnology is 53% which is high as against those that strongly disagreed consisting only 0.6% (low).

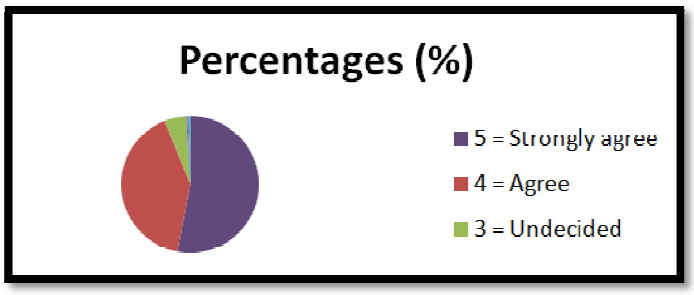

Figure 1

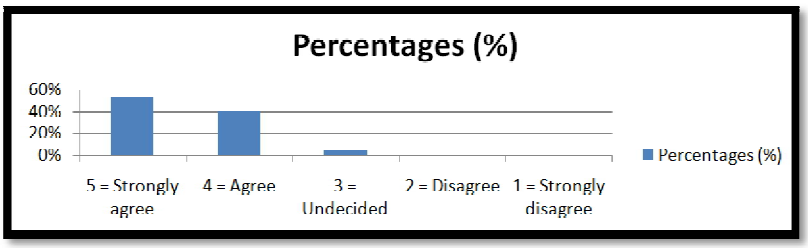

Figure 2

	N	%
Cases Valid	20	100.0
Excluded (a)	20	0
Total	20	100.0
Cronbach's Alpha (α)	Number of Items/Questions	
0.9589	25	

Table 5: Table of Case Processing Summary

a. List Wise Deletion Based on All Variables in the Procedure Reliability Statistics

8. Data Analysis and Presentation of Results

The data were collected with the aid of structured questionnaire presented in Appendix I. The data shows the response of 20 respondents to 25 questions analyzed using the Cronbach Alpha (α)

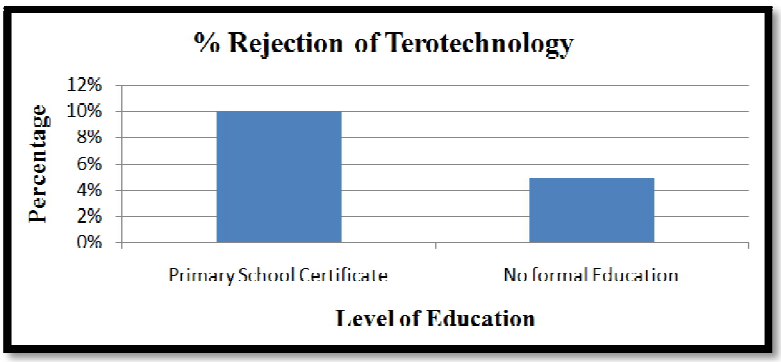

Figure 3

Therefore 85% of the workforce supports the implementation and the practice of Terotechnology in the table water factory in order to improve the day to day running of the table water factory.

9. Conclusion

This study has attempted to show that terotechnology can be applied to the operations of the University of Benin (UNIBEN) Enterprises Table Water Factory to boost its productivity, useful life of its assets and employee competence through relevant training. Questionnaire administered to the employees revealed that the management of the factory practiced some elements of terotechnology with regards to installation, commissioning and record. A good maintenance

practice is also in place but there is still room for improvement such as the adoption of a suitable equipment maintenance plan (EMP) catered for by the practice of terotechnology. The responses indicated that they lacked training which is one area where the management has to pay serious attention as it has the capacity to boost productivity, availability of machines as a result of competent employees especially the maintenance crew, employee job satisfaction and retention. Besides training, it can be concluded that the practice of terotechnology ensures the reliability and maintainability of the factory and its assets throughout their life cycle. In terotechnology, there is no overhauling or complete shutdown of machines. The University of Benin (UNIBEN) Enterprises Table water Factory lends itself to routine maintenance where no overhaul is done. Daily maintenance in the factory involves lubrication of parts, cleaning, tightening of bolts and nuts (where loosened), greasing, checking electrical sockets, replacing parts that are worn out and generally keeping the environment clean before proper production of table water takes place. With proper study of the observations, inexperience on the job, poor skills for operation in automated machine locations, lack of training on expertise, lack of knowledge on safety drills, fire drills, poor method or ways of welcoming new staff, no orientation after recruitment, no motivation packages after conducting interviews were observed. Finally, this study can conclusively say from the analysis of the questionnaires, that the application of terotechnology practices in the University of Benin (UNIBEN) table water factory has improved its productivity.

10. Findings

The following are the FINDINGS and when applied, will improve the operations and productivity of the factory:

- Periodic and task relevant training should be organized for employees of the factory so that they can better perform their job function and increase their productivity.
- Regular safety training and unannounced drills (e.g. fire and other emergencies) should be organized to keep the members of staff emergency ready. Fire extinguishers should be made available with the relevant training on how to operate them given to all members of staff.
- There should be trained and certified first aider among staff with readily available and updated first aid boxes at strategic positions in the factory and its offices.
- On boarding should be practiced in the factory transfer of invaluable and useful knowledge from veteran employees to new employees.
- Unpermitted absenteeism should be discouraged as it lowers productivity and increases the workload and stress on available employees. A clear policy on leave or absenteeism should also be in place and communicated to all employees. This ensures that due process is followed before an employee can be absent from work and management can plan production activities with available manpower. Appropriate disciplinary measures should be put in place and employees should be rewarded for punctuality.
- A proper inventory control system for machine spares should be practiced to avoid costly downtime due to lack of needed spares and an equipment maintenance plan (EMP) should be put in place to properly maintain all machines and other assets of the factory resulting in optimum equipment reliability and uptime.

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