N-Dimension Data Visualization Spaces for Academic Programmes Quality Monitoring in Nigeria Higher Education

Emadomi M. Igbape, *Member, IAENG,* Philipa O. Idogho, *Member, IAENG*

Abstract— **In recent times, especially in Nigeria and other developing countries, numerous factors, hinged on poor financing, inadequate facilities to cope with explosive population of school age children and youth, poor methods of educational services delivering, and globalization issues in education have aggregately affected Quality Assurance (QA) in education. This has continued to draw concerns from government, industry and other stake holders in international education. Regulatory bodies of various nationalities have put in place a number of QA methods and procedures. Implementing these procedures with manual methods does not yield desirable results due to obvious administrative, financial and resources challenges. It becomes necessary to develop and integrate environment specific Information Technology (IT) tools in the administration of education and implementation of QA processes. This paper focuses on visualization of data generated from the multifarious activities and academic transactions in higher education system and models the framework for utilizing these data to achieve desirable QA results. This data visualization spaces forms an integral component of the development of generic application for quality monitoring in Higher Education.**

Index Terms— Quality Monitoring, Performance Evaluation, Data cube, Data Aggregation.

I. Introduction

In the recent past, especially since the mid 1980s, three key issues have been a major source of concern to government, industry and other stakeholders in international education. (1) Rising population of school age children and youth with corresponding decline in budgetary allocation to education, especially in developing nations. (2) Inadequate provision of educational facilities and resources to cater for the increasing population. (3) High mobility of students, academic staff and students in quest of better standards in the face of globalization, new delivery methods and cross-border education providers. Considerable efforts have been made by regulatory agencies of various nationalities to evolve and outline procedures for QA in education. The implementation of most of these procedures has not yielded desirable results. Consequently, it is of the view that serious and conscious effort is needed to develop environment specific IT technologies for school administration and QA monitoring [1].

It is noted that in some countries the national framework for QA, accreditation and recognition of certificates take into account cross-border higher education. In many other countries and mostly developing nations, they are still not geared towards addressing the challenges of cross-border provisions. Furthermore, the lack of comprehensive framework for coordinating various initiatives at international levels, together with diversities and unevenness of the QA and accreditation systems at the national levels, create gaps in the QA of cross-border education [2].

The quality of a country's Higher Education sector and its assessment and monitoring is not only key to the social and economic well being; it is also a determining factor affecting the status of the higher education system at the international level. The establishment of QA system has become necessary, not only for monitoring quality in higher education delivered within the country but also for engaging in delivery of higher education internationally. [3]

Building a QA and accreditation information system requires a clear understanding of the various components that make up the system such as (1) Its purpose, (2) People, (3) Procedures and documentation, (4) The Information Technology and (5) Data. It is the view in this work that understanding the nature and type of data required in QA and accreditation is integral to the development of the system. This work therefore focuses on visualization and modeling of the data in QA monitoring and accreditation system based on the NUC-MAP which categorizes the criteria for accreditation of degree programmes in Nigeria universities [4].

It is hoped that the data analysis, visualization and modeling will be a tremendous resource upon which the QA and accreditation information system would be built.

II. BACKGROUND TO THE STUDY

A. *Quality Monitoring in Nigeria Higher Education*

One of the fundamental steps in designing IT based system for pursuing QA and accreditation in education is a clear understanding and visualization of the types and structure of data generated by the QA processes. The data visualization and modeling presented in this work is based on two main data acquisition documents contained in the Nigerian Universities Commission (NUC) Manual of

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Dr. Emadomi Moses Igbape was formally Head, Department of Statistics and Computer Science, formally Director, Management Information System, and presently Chief Lecturer Department of Computer Science, Auchi Polytechnic, Nigeria. Email: emadomi2@yahoo.com, emigbape@auchipoly.edu.ng. Dr (Mrs) Philipa Idogho was formally Head Department of Office Technology, Dean School of Evening studies, Rector, Auchi Polytechnic and presently Chief Lecturer, Department of Office Technology, School of Information and Communication Technology, Auchi Polytechnic.Email: philipaidogho@yahoo.com,

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Accreditation Procedures (MAP) [4]. These are the NUC Self Study Form (NUC/SSF) and the NUC Programme Evaluation Form (NUC/PEF).

The NUC is empowered legally for accreditation of degree programmes in Nigeria Universities by decree No. 16 of 1985 section 10 and its subsequent amendment incorporated in section 4(m) of NUC Amendment Decree No. 49 0f 1988. MAP defines accreditation of degree and other academic programmes by NUC as a system for recognizing educational institutions (Universities and programmes offered in these institutions) for a level of performance, integrity and quality which entitles them to the confidence of the educational community, the public they serve and employers of labour. The NUC/MAP document outlines the objectives of accreditation of academic programmes in Nigerian Universities to include; (1) Ensuring that at least the provisions of the Minimum Academic Standards (MAS) document are attained, maintained and enhanced; (2) Assuring employers and other members of the community that Nigerian graduates of all academic programmes have attained an acceptable level of competency in their areas of specialization; and (3) Certifying to the international community that the programmes offered in Nigerian Universities are of high standards and their graduates are adequate for employment and for further studies. It categorizes the status of accreditation into (a) Full Accreditation; (b) Interim Accreditation; and (c) Denied Accreditation. It stipulates the criteria for attainment of any of the categories of accreditation mentioned.

The NUC/PEF [4] outlines 6 (six) components which form the performance indicators that are used to carry out assessment of academic programmes. They are;

(1) *Academic Matters :-* (i) The Programme Philosophy and objectives; (ii) The Curriculum; (iii) Admission Requirements; (iv) Academic Regulations; (v) Course Evaluation; (vi) Student's Course Evaluation; (vii) External Examiner's System.

(2) *Staffing:-* (i) Teaching Staff; (ii) Non-Teaching Staff; (iii) Head of Department/Discipline/ Sub-Discipline.

(3) *Physical Facilities:-* (i) Laboratory/Studio/Clinic Facilities (area per student) and Equipment; (ii) Classroom Facilities and Equipment; (iii) Office Accommodation (area per staff) and Equipment; (iv) Safety and Environmental Sanitation.

(4) *Library:-* Books, Journals and other resource materials for the programme including e-learning facilities.

(5) *Funding:-* Funding of programme by the University.

(6) Employers' Rating of Graduates.

Numeric values are assigned as weights to each of the evaluated Performance Indicators. Assessment scores are awarded to each of the Performance Indicators by each member of the accreditation team. The scores are aggregated and used to classify the performance of the programme under consideration.

B. Data Cubes

Data cube is used to represent data along some measure of interest. Even though it is called a 'cube', it can be 1-dimensional, 2-dimensional, 3-dimensional, or higher-dimensional, where the cells in the cube represent the facts of interest. Data cube concept was applied to describe time-varying business data as data cubes by Jim Gray, et al, [5]

More often than not, especially when dealing with data that have multiple dimensions including time dimensions, users visualize the data as multidimensional database in the shape of a cube as shown in figures 1-5. When users access a data in a multidimensional database of this nature, their queries usually involve aggregate data, such as total sales by month and average sales by customer. As users view the aggregate results from their queries, they often need to perform further analyses of the data they are viewing. Users' analysis, typically involve actions that include the following; (i) Slice and dice; (ii) Drill down and (iii) Roll up. [5].

The concept of Data cube has been used in this work because of its viability in handling time-varying large business data such as the type of data encountered with the use of the NUC/PEF for programmes accreditation.

C. Organizing Data in Multidimensional Arrays [6]

Multidimensional arrays are an extension of the normal two-dimensional matrix with the row dimension and the column dimension as shown in Figure 1.

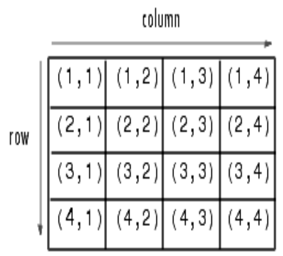

Figure 1. Two-dimensional Array

Multidimensional arrays use additional subscripts for indexing. A three-dimensional array uses three subscripts. (i) The first references array dimension 1, the row; (ii) The second references array dimension 2, the column; (iii) The third references array dimension3. This illustration uses the concept of a page to represent dimensions 3 and higher as shown in Figure 2.

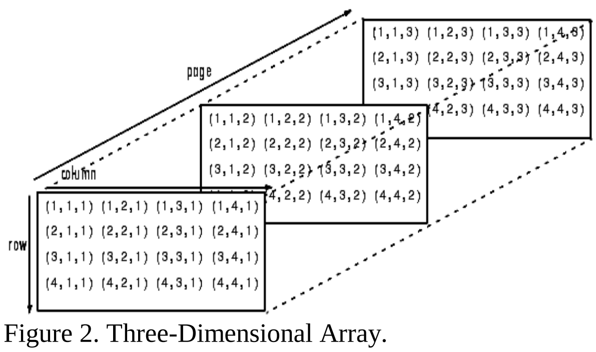

Figure 2. Three-Dimensional Array.

Elements in the second row, third column of page 2 can be accessed with the subscript (2,3,2). We can use multidimensional arrays to represent data in two ways. (i) As planes or pages of two-dimensional data. Each page can then be treated as matrices. (ii) As multi variant or

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multidimensional data. Summarization or aggregation operations can be performed on the data in either of the instances.

III. MODELING APPROACH

Harmonizing educational qualifications across nationalities remains a real life problem. This derives from the fact that quality and standards vary from one nation to another. There are no uniform procedures for monitoring quality in the face of proliferation of cross-border education providers, internationalization and trends in online delivery of educational services.

The final goal of this work is to produce QA information system that can be used online by supervisory agencies. To achieve this, the approach in this work is to study the QA instruments of NUC in order to determine the nature of QA data and visualize its representation and conceptualize the operations and queries that can be used to generate needed information from the data.

IV THE CONCEPTUAL DESIGN

Data modeling tools provide the Software Engineer with the ability to represent data objects, their characteristics and their relationships. This is used primarily for large Database administration and other Information Systems projects. [7]

After a careful study of the NUC/MAP document and observation of actual accreditation processes, data concepts have been formulated to include; (i) Visualization; (ii) Identification of Attributes and; (iii) Conceptual design

A. *Visualization of Data*

Visualization and analysis tools do ‘dimensionality reduction’ often by summarizing data along the dimensions of interest. For example, the performance of an Academic Programme can be analyzed to focus on the roles of Programme of Study, Performance Indicators and Year. The overall performance of a programme across the Performance Indicators by Year may be analyzed. [3].

Each programme to be visited can be visualized as a plane or page of two-dimensional matrix. The Performance indicators form the rows, while the time in years form the columns. In the sample case study for this work, we have six rows representing the six performance indicators, four columns representing the time or four years duration and four pages representing four academic programmes to be visited.

Figure 3 shows 3-Dimension Data Cube visualization of data generated from the NUC/PEF accreditation instrument.

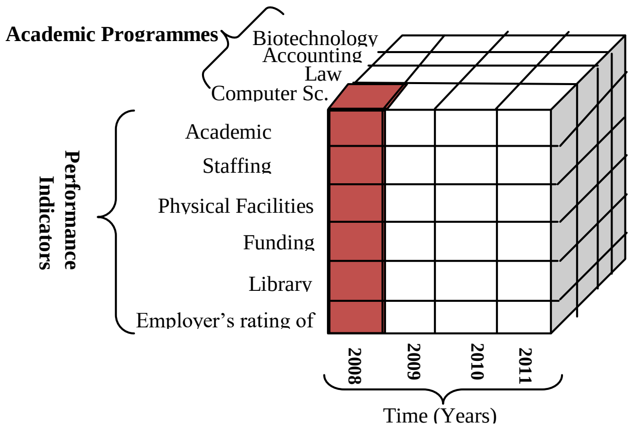

Figure 3. 3-Dimension Data Cube Visualization of NUC/PEF assessment data.

The shaded portion of Figure 3 indicates a 1-Dimension Data Cube showing the performance of Computer Science for the year 2008 across all Performance Indicators.

It is also possible to analyze the performance of a selected indicator in Computer Science over the 4 years period under consideration as illustrated in Figure 4.

The shaded portion in Figure 5 shows the 2-Diemension Data Cube visualization of the performance of Computer Science in all Performance Indicators across the 4 years period covered by the accreditation exercise.

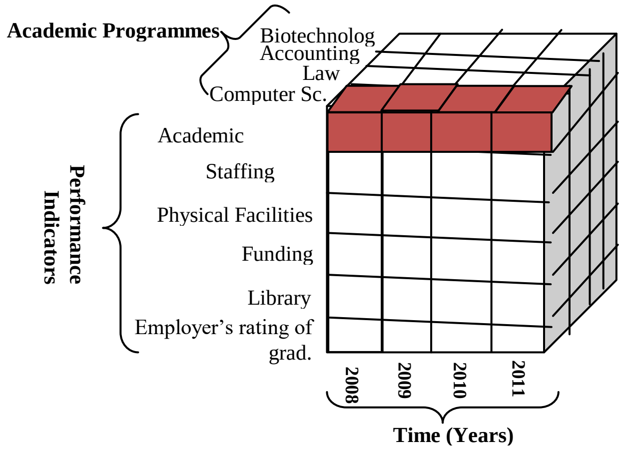

Figure 4. Performance of Computer Science in Academic Matters across the 4 years period.

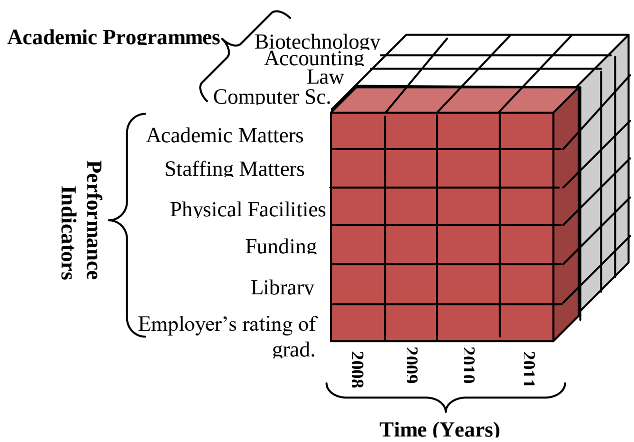

Figure 5. 2-Dimension Data Cube showing performance of Computer Science across all Performance Indicators over the 4 years

B. Identification of Attributes

A number of tables are conceptualized, with the entities and attributes that make up the structures.

To realize this data concept, various tables are conceptualized in this work. Figure 6 shows the schema for the database relations.

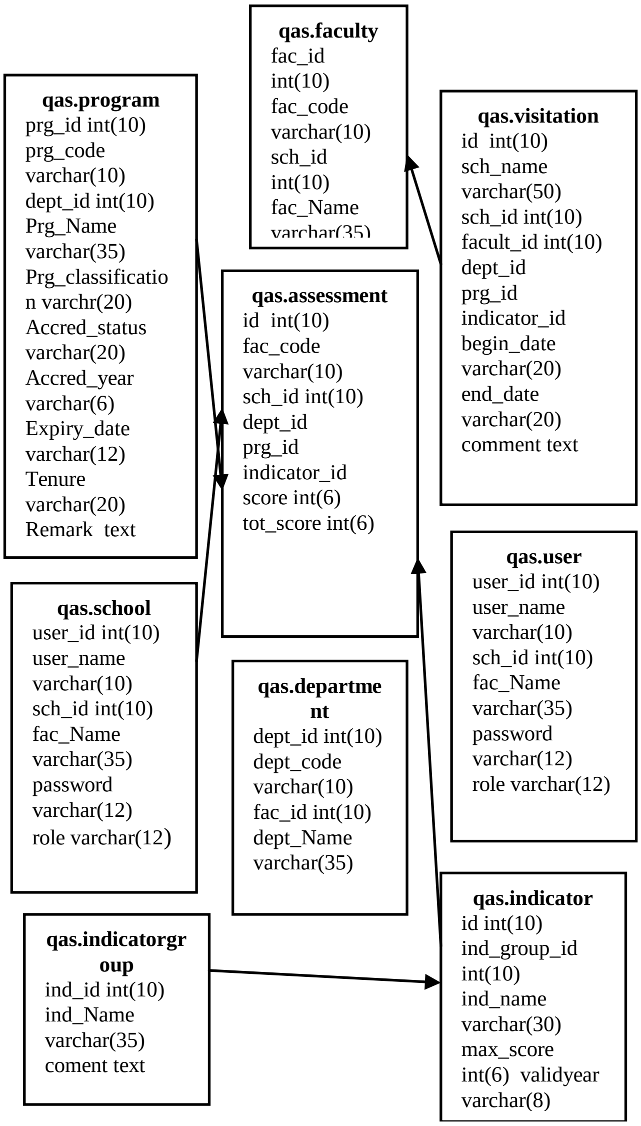

Figure 6. Schema for the database relations

C. Performance Evaluation

The Accred_Year attribute in qas.program translates the table into a 3-Dimensional Data cube. All Performance indicators in a programme for accreditation can be analyzed over the 4-year period under study. This translates into a 3-Dimensional Data Cube with three intersecting crosstabs. Creating a data cube requires generating the power set (set of all sub-sets of all aggregation columns).

The cube as an **aggregation operator** is a relational operator with group-by and roll-up as degenerate forms of the operator.

Based on the Accreditation case scenario studied in this work, a sample conceptualized Table for Academic Matters performance indicator, derived from the data gathering instrument, the NUC/APRF is presented in Table 1 .

Table 1. Sample Assessment for a Programme

Performance Index	Maximum Score	Score Obtained
Philosophy & Objective	2	1
The Curriculum	3	3
Admission Requirements	3	3
Academic Regulations	2	2
Standard of Tests & Exams	3	2
Students' Academic Work	3	2
Practical Work/Projects	3	2
Students' Course Evaluation	2	2
External Examination System	2	2
Total Score	23	19

Similar Tables can be generated for the remaining 5 (five) Performance Indicators for each corresponding year.

From the sample assessment reviewed in this study, Table 2 shows the sample assessment scores for Computer Science for 4 years; 2008, 2009, 2010 and 2011.

Table 2. Sample Assessment Scores for Computer Science

YR	ACAD. MATTERS	STAFF	PHY. FACIL.	FUND.	LIB.	EMP	TOT. %
2008	82.607	59.375	56	20	58.33	66.667	57.16
2009	73.913	65.625	68	40	66.67	66.667	63.48
2010	65.217	71.875	80	70	75	66.667	71.46
2011	69.565	84.375	84	60	75	83.33	76.15
	72.83	70.313	72	47.5	68.75	70.83	67.04

We can find answers to queries such as; (i) what is the performance rating of Computer Science across all performance indicators for 2008? This query is a 1-Dimensional data cube that can be achieved with the SQL command in listing 1 with result set in table 3.

```
SELECT Programme, Year, 'ALL', SUM (Perf._Mearsure)
AS Perf._Score, Max_Score AS Max_Score
FROM Assessment
WHERE Programme in ('Computer Sc.' ) AND Year in '2008'
GROUP BY Programme, Year
```

Listing 1. Sample SQL Statement for example 1

Table 3. Result set for example 1

Programme	Year	Perf. Indicator	Performance Rating (%)
Computer Science	2008	ALL	62.02

(ii) What is the overall performance of Computer Science across all indicators and years? This is used to determine the accreditation status of the programme.

To determine the accreditation status, i.e overall performance of a Programme, the GROUP BY CUBE operator is used on the 3-Dimensional Data Cube indicated in Table 2. The syntax of the cube statement is shown in listing 2.

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```
SELECT Programme, Year, Perf_Indicator, SUM
   Assessment_Score AS  Perf_Score, Total_Score AS
   Total_Score
FROM Assessment
   Where Programme in (‘Computer Sc.’,
   ‘Law’,’Accountancy’, Biotechnology’
AND  Year.ALL
GROUP BY CUBE Programme,Year, Perf_Indicator
```

Listing 2. Sample Cube Statement

The result set for the SQL statement in listing 2 is shown in table 4.

Table 4. Final rating of Computer Science

Programme	Year	Perf. Indicator	Performance Rating (%)
Computer Science	ALL	ALL	67.037

The full discussion of the Cube Statement is fully covered in Grey et. al [4]. The operator is used in this work to extend the visualization spaces to N-Dimension. The three-tier system architecture presented in [8] can be used to create frontend data capture interfaces for data acquisition and backend databases. Developers can create applications for frontend users and the logic/query processing layer using technologies provided by the .NET development environment and the .NET framework Software Development Kit (SDK).

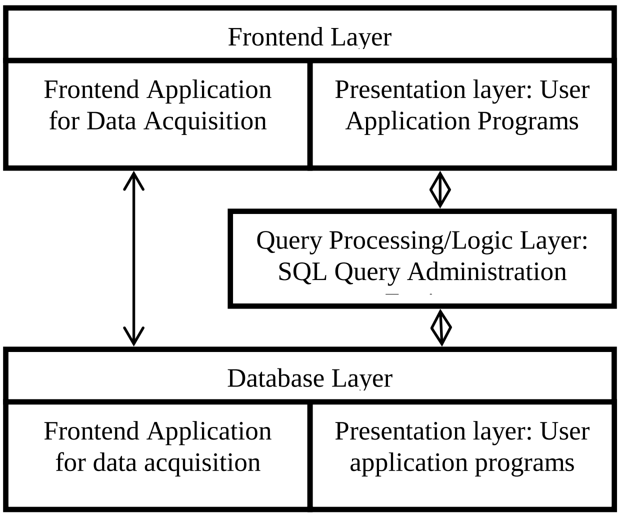

Fig. 5. System Architecture (Source: Authors’ work [9])

V. CONCLUSION

It is observed that a clear understanding of the nature, type and structure of data generated from the multifarious transactions in academic environment is integral to the development of a viable QA information system. This work has carried out a critical study of the QA processes in Nigeria Higher Education sector with a view to providing a data framework upon which a viable QA information system can be built.

The NUC/MAP has been studied to derive the data concepts and visualization presented in this qork. It is hoped that this concepts and visualization will be of immense benefit to developers and further work in this research initiative.

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