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NETWORK ANALYSIS: A TOOL FOR EFFECTIVE MANAGEMENT OF EDUCATIONAL SYSTEM IN NIGERIA

¹MUSTAPHA ADAM ISHOLA, ²YUSUF SULEIMAN, ³LAWAL ABDULMUMIN ABUBAKAR & ⁴LAWAL ADE ALIYU

¹Department of Educational Management, Faculty of Education, University of Ilorin, Ilorin

^{2&4}Department of Educational Management and Counselling, Al-Hikimah University, Ilorin, Nigeria

³Department of Educational Management, Faculty of Education, University of Ilorin, Ilorin

Corresponding Author: Yusuf Suleiman, yusufsulaiman@alhikimah.edu.ng

Abstract

Educational system in the contemporary epoch is characterized by a growing and complex of range of interrelated organizations which has expanded globally and positioned in the educational policy domain. The basic assumptions for social phenomenon are yielded by analysis of the relationship among entities. Thus, the notion of network analysis paradigm is central to appreciate contemporary changes in the management of educational system. Thus, this paper examined network analysis as a tool for effective management of educational system. It developed a discussion of network concept and proposes more systematic less normative ways of addressing and researching network issues in education. It equally looked in to the key dimensions of inter organization networks and make case for more comprehensive research approaches to these phenomena. Besides, the fundamental procedure behind fashionable educational management paraphernalia designed to handle multifaceted and time sensitive operations among which are critical path method, critical chain method and programme education and review technique were examined consecutively. The paper concluded that magnitude of network analysis as a means to capture emerging dynamics of educational system has been subjected to overhaul reformation, curriculum restructuring, policy formulation and pedagogical strategies. It was recommended among others that network analysis should be increasingly channeled in the administration of education system through the mechanism of knowledge mobilization.

Keywords: Network Analysis, Panacea, Effective Management and Educational System.

Introduction

Initiative to streamline and re-culture educational system through intra and inter institutional networks has grown in number in recent years. Network is a fashionable and current term in every field of contemporary society and education is not an exemption. Network of teachers and schools often linked to institutions outside education are becoming key focus of change efforts promoted by professional and policy makers. However, in current research the use of network analysis has been generally vague, normative and mostly instrumental (Hoppe, Harrer, Göhnert & Hecking, 2016; Hosseini, Maghrebi, Akbarnezhad, Martek & Arashpour, 2018; Lin, Tai, Tiong & Sim, 2016; Zheng, Le, Chan, Hu, Y., & Li, 2016). Watts (2013) affirmed that the status of network analysis as a methodological and conceptual tool in educational industry continue to expand speedily. The rise in popularity is reflected in the expanding quantity of educational resources to provide the general overview that constitute the sector. Contemporary educational managers are faced with plethora of problems regarding motivation of teaching and non-teaching staff to enhance efficiency and effectiveness. To perform these tasks, several



methodologies, techniques and strategies were developed by the managers for evaluating people opinions and one of these is network analysis.

The core technique for effective educational planning requires careful thought and application of logic of network analysis (Van Engeland, Beliën, De Boeck, De Jaeger, 2020). Carlon (2016) opined that network perspective is shaped by theoretical and mathematical insights from numerous disciplines in the natural, social and behavioral science. However, it is being widely applied in the contemporary era in educational setting. Thus, it is used by educational researchers to observe phenomenon that range from teachers' espousal of new technologies, the diffusion of attitudes towards school reforms among district heads and peer influence on classroom behavior of elementary students. The increase adoption of network analysis by educational researchers is ascribed to frustration with attribute based theory of individual behaviours and attitudes, inherent educational social phenomenon. Ya-Rui & Ding (2016) are of the view that educators are interested in curriculum reform, promoting social equality in student interaction, fostering connections between classrooms and enhancing teaching pedagogy, which are easily achievable through network analysis.

Concept of Network Analysis

There is no consensus of opinions among scholars regarding the definition of network analysis. It is a general name given to certain specific techniques used for the planning, management and control of project (Beasley, 2009; Park, Lee, Kim & Lee, 2018; Serrat, 2017; Ya-Rui & Ding, 2016). According to Mania (2015), network analysis is a group of special analytical technique employed in case where it is necessary to analyze and optimize a network of interconnected and related elements that have connection with one another. Generally speaking, it is any structure technique used to mathematically analyze a circuit (a network of interconnected components). According to Business Dictionary (2016) network analysis is the breaking down of a complex project data into its component parts or events and plotting them to show their interdependencies and interrelationship. Network analysis as a process serves as basis of several unique analytical techniques. It is a graphical representation consisting of certain figuration of arrows and nodes for showing the logical sequence of various tasks to be performed to achieve the desired goals. Borgth (2005) affirmed that network analysis refers to social systems that center on effective conceptualization and thoughtfulness of explosion of interest across social systems in network research regarding the relationship among the entities which constitute the system through quantitative structural approach.

Muritala, Ajibola, Oladimeji and Lawal (2010) remarked that network analysis as a management techniques used to combine resources and control activities for implementation of plan. It is a generic term for a family or related techniques developed to aid management in planning and controlling process. This model is suitable for projects that are not of routine or respective in nature. It can be applied to education project in the areas of building, construction, teaching personal, facilities equipment and the like. It has some inbuilt methods that are used to avoid unnecessary conflicts and delays to ensure that all events and activities as well as their interrelationship are kept. International Encyclopedia of Behaviour and Social Sciences (2015) remarked that network analysis is a set of strategies to demonstrate data and way of studying the social machinery through which key market tribulations get resolved. Antonio (2015) remarked that network analysis connotes a set of technique

with a communal procedural perception which permit researchers to portray relationships among factors to evaluate the societal structures that appear from the reoccurrence of relations. The prominence of network analysis is a unique phenomenon in the management of educational system and one of most value where there are recipe of interconnected tasks, where many types of facilities, high capital investment and many personnel are involved and where restriction exists: where projects have to be completed within stipulated time, cost limit or limited resources.

Network Analysis Methods

Network Analysis methods are groups of analytical techniques which are used in cases where it is necessary to analyze and optimize a network of interconnected and related elements that have connection between one another. Nigeria educational system has witnessed a multiplication of programmes that were designed at one time of the other to serve the need of a particular society (Kalyagin, Koldanov & Pardalos, 2016; Meuser, Gardner, Dinh, Hu, Liden & Lord, 2016; Soheilrad, Govindan, Mardani, Zavadskas, Nilashi & Zakuan, 2018). Sometimes, these programme failed to meet the society needs, due to the failure of the designers to link the components together which will allow for the correction of the mistakes that might have been committed in one stage. Among the basic network analysis methods include;

- i. Critical Chain Method (CCM)
- ii. Critical Path Method (CPM)
- iii. Programme Education and Review Techniques (PERT)
- iv. Graphical Evaluation and Review Techniques (GERT)
- v. Metra Potential method

Critical Chain Method

This is defined as the longest path from start point to final point of the chart which takes into account the capacity constraints of the resources. CCM is also known as Critical Chain Project Management (CCPM) that views any manageable system as being restricted towards the accomplishment of the set goals with little constraints. Each project has at least one critical chain with list of activities which the project manager would focus most for timely completion of the project. This technique was developed by Godratt in 1997 in his book titled "Critical Chain aimed at determining the duration of the project based on the length of the critical chain, accessibility and availability of resources, sequence of interdependent activities and constraint of resources.

Uses of Critical Chain Method

- i. It facilitates effective time management of individuals.
- ii. It mutually follows activities within project
- iii. It ensure proper planning of requires educational resources
- iv. It is reflected in time planning and project management in virtually all phases of project life cycle.

Critical Path Method

This is a step-by-step project management technique for process planning that defines critical and non-critical tasks with the goal of preventing time frame problems and progress bottle necks. Haytes (2000) defined it as a standard various projects whose completion involve the performance of a number of tasks and corresponding sequence. It is ideally suited to project consisting of numerous activities that interact in a complex manner. The identification of part which determines when the projects can be completed is known as critical path method. Critical path method was developed in 1957 by Dupoint, Morgan, James and Kelly of Remington Rand with emphasis on the trade-off between the cost of the project and its overall completion time. It was firstly used in missile defense constitution project and later adapted to other fields including hardware and software product research and development, aerospace and defence and any interdependent activities.

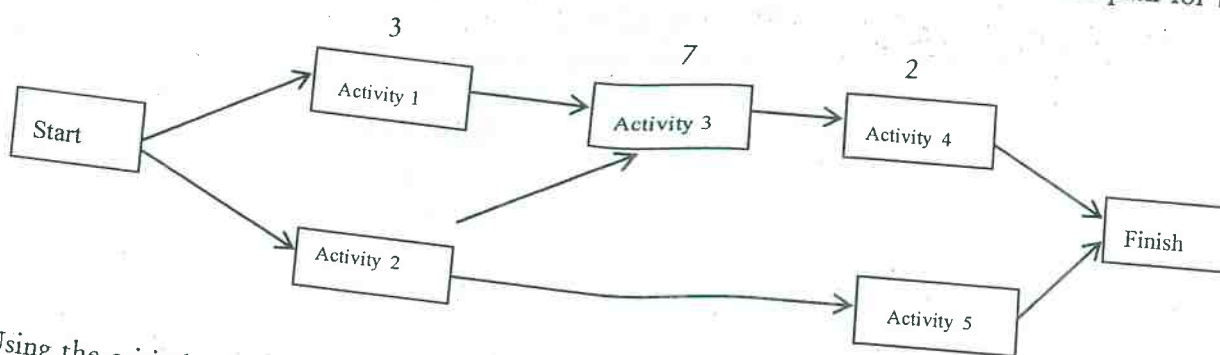
Steps Involve in Critical Path Methods.

1. Define the require task and put them down in order or sequence.
2. Create a flow chart showing each task in relation to one another.
3. Identify the critical and non-critical relationship among task.
4. Devise alternatives for the most critical path method

Elements of Critical Path Methods

- i. Critical Path Analysis.
- ii. Float Determination.
- iii. Early Start and Late Finish Calculation.
- iv. Early start and late Finish Calculation.

The critical path is the sequence of activities with the longest duration. A delay in any of these activities will result in the delay of the whole projects. Below are examples of critical path for better understanding of key elements:



Using the critical path method (CPM), the duration of each activity is listed above each node in the diagram. For each path, add the duration of each node to determine its total duration. The critical path is the one with the longest duration.

There are three paths through this project:

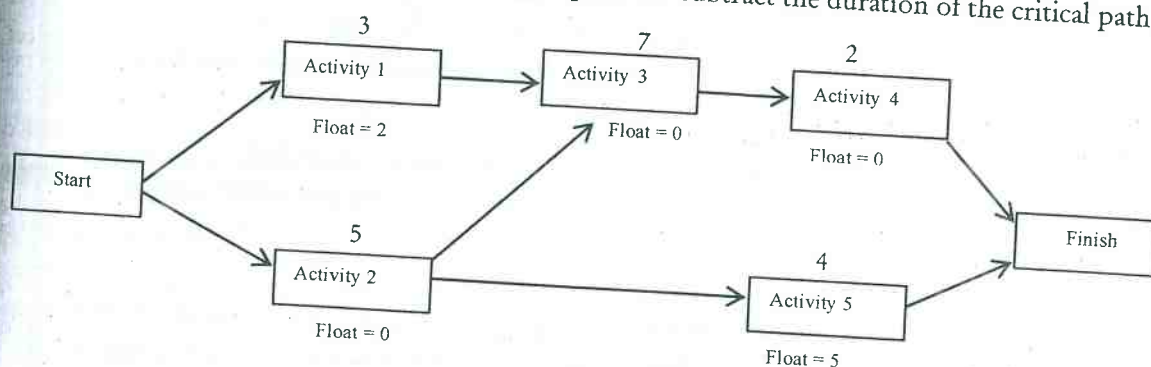
Start → Activity 1 → Activity 3 → Activity 4 → Finish $3 + 7 + 2 = 12$



Start → Activity 2 → Activity 3 → Activity 4 → Finish $5 + 7 + 2 = 14$
 Start → Activity 2 → Activity 5 → Finish $5 + 4 = 9$

Float Determination

Float is the amount of time an activity can slip before it causes project to be delayed. It is sometimes referred to as slack. Figuring out the float, using the critical path method is fairly easy. Each of those activities has a float of zero, take the next longest path and subtract the duration of the critical path.



Using the critical path from the diagram above, activities 2, 3 and 4 are on critical path so they have a float of zero. The next longer path is activities 1, 3 and 4 and their float will remain as zero. The float is the duration of critical path minus the duration of this path $14 - 2 = 12$. Activity 1 has the float of 12.

The next longer path is activities 2 and 5. 2 is on the critical path so it will have a float of zero. Activity 5 has float of $14 - 9$, which is 5. so as long as activity 5 does not slip more than 5 days, it will not cause a delay to the project.

• Early Start and Late Finish Calculation.

The critical path method includes a technique called the forward pass that determine the earliest date an activity can start and the earliest date it can finish. The early start (ES) of the first activity is one and the early finish (EF) of an activity is its ES plus its duration minus 1. $ES = 1$, $EF = 1 + 5 - 1 = 5$.

ES is the previous activity $EF + 1 = ES = 5 + 1 = 6$, its EF is calculated as $EF = 6 + 7 - 1 = 12$

• Late Start and Late Finish Calculation.

The late finish of (L5) is the LF-duration + 1. From the example above, activity 4 is the last activity on the critical path. Its LF is the same as its EF, which is 14. To calculate the LS, subtract its duration from its LF and one $LS = 14 - 2 + 1 = 13$.

LF in activity 3 = $13 - 1 = 12$. Its LS is calculated by subtracting its duration from the LF and adding one. Activity 3 $LS = 12 - 7 + 1 = 6$.

Programme Evaluation and Review Techniques: this is commonly abbreviated as PERT is a statistical tool or method of analyzing the activities concerned with completing a given project, especially the time needed to complete each task and identify the bare minimum time required to complete the total project (Kharanagh, Banihabib & Javadi, 2020; Li & Law, 2020; Pinarbasi, 2020; Yousefi, Nooraie, EM



Sale, Marin & Ross, 2020). According to Robbert (2006) programme evaluation and review techniques minimize conflicts, delay and interactions in projects and coordinate various part of the overall job. It is a statistical technique for measuring and forecasting progress in research and development programme for which time is a critical factor. Maritala, Ajibola, Oladimeji and Lawal (2010) view it as the maximization and utilization of human and material resources as well as elimination of idle equipment and time.

In a nutshell, PERT is a management control tool that sizes up the outlook for meeting objectives on the time, highlight dangers signals requiring management decisions, reveals and defines the network of sequential activities that must be performed to meet objectives and stimulate the effect of option for decision.

The concept of PERT was developed by an Operational Research Department team staffed with the representatives from the operational Research Department of Booz, Allen and Hamilton: the evaluation office of Lockheed Missile system division in 1958 to support the special project office of the United States Navy's Polaris nuclear sub-marine project. PERT was introduced and used in conjunction with critical PERT method. It was developed primarily to simplify the planning and schedule of large and complex projects and applied as a decision making tools to save time in achieve estimate range of time necessary to complete activity between two successive events.

The project model was the first of its kind revival for scientific management (Taylorism) which was later refined by Henry Ford (Fordism). Dual point's critical path method was invented at roughly the same time as PERT. The technique takes recognition of three factors that influence successful achievement of research and development programme.

Steps involve in objectives: time, resources and technical performance,

Specifications involved in PERT

- i. Find out the material to use.
- ii. Schedule the time to take.
- iii. Determine the sequence of the programme.
- iv. Reduce the task of the network for the completion of the programme.

Characteristics of PART/CPM

- i. Existence of established standard sequence time for finding solution to production and maintenance problems.
- ii. They are basically time oriented in nature.
- iii. They are cost saving techniques
- iv. They are essential and critical for the realization of the set objectives.
- v. Both are problem solving techniques.

Stages involve in PERT/CPM

The methodology involved in network scheduling by CPM/PERT consist of four stages:

Planning stage: this is when the whole project is splitted into smaller projects and analyzed by a department or section. The relationship of each activity with respect to other are defined and established.

Scheduling stage: this is a stage that gives the earliest and the latest allowable start and finish time of each activity as well as its relationship with other activities in the project. It pin point the activities required special attention if the project is to be completed in time.

Resource allocation stage: this is a stage where physical variable (labour, finance, space and equipment) that impose a limitation for project completion is performed to achieve the desired objective.

Controlling stage: the final stage phase in the projects management is controlling. The project is controlled by checking progress against the schedule, assigning manpower and equipment and analyzing effects of delay.

Difference between PERT and CPM

Programme evaluation and Review Technique (PERT) and critical part methods (CPM) are basically time oriented methods laid to determine time schedule for project. However, line for demarcation can be made between them on the following areas:

- i. PERT is probabilistic, while CPM is deterministic.
- ii. PERT is event oriented, while is the activity oriented.
- iii. PERT is non-base on experience, while CPM is based on experience.
- iv. PERT focuses on multiple time, while CPM focuses on single time estimates.
- v. PERT is non repetitive in nature, while CPM is repetitive in outlook.
- vi. PERT is uses on predictable activities, while CPM uses predictable activities.
- vii. PERT is time base, while CPM is cost based.

Advantages of PERT /CPM

- i. PERT chart explicitly defines and makes visible dependencies the work breaking structure.
- ii. PERT facilitate identification of the critical path and make it visible.
- iii. PERT facilitates identification of the early start, late start and slack for each activity.
- iv. PERT provides for potentially reduced project duration and improved overlapping of activities whose feasible
- v. Creation of awareness on educational policies.
- vi. Organization and presentation of projects data for use in educational decision making.

Challenges of PERT/CPM

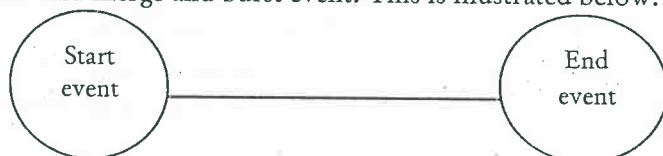
- i. They are not easily scalable for similar project.
- ii. The network charts tend to be large and unwieldy requiring several pages to print and requiring specially sized paper.
- iii. The techniques rely on past data and experience to completion time prediction.
- iv. There can be potentially hundreds or thousands of activities and individual dependency relationship.
- v. When the PERT/CPM charts become unwieldy, they are no longer use to manage the project



Basic Network Terminologies

Activity: this is an individual operation which utilizes resources and has a beginning and end. It is the actual performance of tasks which consume time and require resources. An arrow is used to depict an activity which its head indicates the direction of progress in the project. Activity is of four types namely: predecessor, successor, concurrent, and dummy activity.

Event: the beginning and end points of an activity are called events, nodes, or connectors. It consumes no time and uses no resources and is often represented by a circle in a network. It can be a merge event, burst event, and merge and burst event. This is illustrated below:



Float or slack: This is a measure of the excess time and resources available to complete a task. It is the amount of time that a project task can be delayed without causing a delay in any subsequent tasks (free float) or the whole project (total float).

Critical path: This is the sequence of activities with the longest duration or the longest possible continuous path taken from the initial events to the terminal event.

Critical activity: this is an activity that lies on the critical path and has a total path equal to Zero.

Fast tracking: - This refers to performing more critical activities in parallel.

Network diagram: This is a graphical representation and logical sequence of various tasks to be performed to achieve project objectives. It also means the pictorial overview that clearly and concisely represents the entire activities and their relationship.

Early start time: this is the maximum or positive time at which all succeeding activities can commence. It is used to determine the earliest date an activity can start. It is also known as forward pass.

Early finished time: -This is the latest possible time at which a preceding activity can finish without increasing the project duration.

Application of network analysis in education industry

Network analysis examines network structure quantitatively to better understand network functions. It provides the necessary tool kit for investigating questions involving relational data. Network analysis serves as a set of theoretical and methodological approaches that help to answer questions on equity, educational process, programme learning, review and implementation of educational policies. It gives a base line understanding of the classroom network norms and illuminates major aspects of learning.

Methodological Approaches to Network Analysis

Borgatti (2015) remarked that network analysis can be approached using a diversity of approaches, but the most prominent approaches are:

Social Network Analysis: This is the most conventional technique in network analysis which is extensively espoused in a range of fields including educational enterprise that allows the researchers to study the centrality of actors so as to understand the budding influence that an actor might exert due to the capacity to distort what is passed along in an attempt to serve the interest of the actor. SNA is widely adopted in physical and social sciences and has exposed a multiplicity of germane findings from the way in which the society functions to the productivity of organization (Borgatti, 2015).

Bibliometrics: this is an approach to network analysis inform of written publications. It examines data from citations in order to track published literature and recognize variety of models and clusters in a particular research field (Estabooks, 2008). This technique gives room for cross fertilization of ideas in publications and references cited in different researches to measure individuals output, research team and institutions as a means exploring the arrangement in different research areas and academic fields. Goldie (2014) substantiated that bibliometrics method is an emerging method in both comparative education and policy.

Network Ethnography: this is a rigorous approach to network analysis that allows for collaborative value of arrangement in global educational research. It centrally base measurement not on mere number of connections, but also weighs it through hierarchical policy making space.

Scholars in the field of education have applied network analysis to examine wide range of issues among which are tertiary education expansion, global networks of universities as well as influence of social capital on students academic performance.

The network analysis can be applied in educational industry when:

- i. Educators are interested in curriculum review and development.
- ii. New teaching methods are to be introduced.
- iii. New educational policies are to be introduced
- iv. A sensitization programme or awareness creation is to be embarked upon.
- v. Social equity in students' interaction id to promoted.

Conclusion

Educational system in the contemporary era is characterized by a growing and complex of array of interconnected organizations which has globally positioned networks in the educational policy domain. The notion of network analysis is fundamental to the appreciation of contemporary phenomenon in policy making process and governance structure in educational system. Network analysis offers a uniquely fitting approach to the study of educational system characterized by the rising and comprehensive display of interconnected organizations which is globally positioned in the educational policy domain. The magnitude of network analysis as a means to capture emerging dynamics of educational system has been subjected to overhaul reformation, curriculum reform, policy formulation and pedagogical strategies. Despite being developed with regard to relatively policy scenario, network analysis has captured emerging dynamic of educational policy change more broadly and provides researchers with conceptual and analytical tool to approach elusive concepts systematically as well as assisting education policy makers and practitioners to be aware of recent development in the educational industry.



Recommendations

Based on the study, the following recommendations are made:

- i. Network analysis should be increasingly channeled in the administration of education system through the mechanism of knowledge mobilization.
- ii. The rising presence of network in global educational context needs to be explored to reflect the dynamism in the sector.
- iii. Capacity building programmes like: seminars, workshops and conferences that focus on foundational issues, fundamental concepts and mathematical representation on network analysis should be periodically organized for educational managers for effective service delivery.

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