Chapter 38
Application of Complexity Theory as Recipe for the Chaotic Nigerian Educational System: Exploration in the Context of Sustainability

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Abstract Education is seen as a means of effective change, in the social and cultural context, but as a system, it has fallen short of this requirement in Nigeria. The current educational system which enacts vocational and socializing roles or functions has led to greater emphasis on paper qualification and has made the system, highly dysfunctional. This paper, drawing its methodological strength mainly from review of relevant literature, submits that Instead of strengthening the ideal of its intrinsic value, worthy of its transformative essence, the system has cultivated instrumental values that further eroded its true purpose towards nation building. This indeed is indicative of chronic and acute problems that signify system failure and it truly calls for corrective thinking and action. The paper thus, tries to explore the situation, from the systems theory perspective, by conceptualizing the Nigerian education system as a Complex Adaptive System (CAS) by virtue of its complexity as a human and social system. It also envisages the possibility of adopting the complexity theory as an approach, in order to bring about conditions necessary for the much needed educational sustainability in Nigeria.

38.1 Introduction

Chaos is in fact an aspect of reality that proves almost present all the times and in every setting albeit with varying degree of influence in especially enabling the system discover its weaknesses hence a platform for redefinition of strategies,

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adoption of appropriate leadership solutions on one hand, and/or disallowing the system the utility of any possible alternative that can see the system to transforming any perceived adversity into advantage. In the same respect, it is worth noting that an environment characterized by multiple actors, either human or non-human, that allows for, mutual co-existence, interrelation, interdependence with one another at various levels of interaction and varying dimensions, has the tendency to embody complexity in all ramifications of its being. This description of the environment is consistent, with the idea of a system whose features are drastically opposed to the established idea, of linearity and feedback typical of a simple system.

Instead, such a system represents a more complex idea exhibitive of non-linear relationship of system actors or components rooted in an atmosphere of continuous interaction, between elements of the system across varying dimensions of relatedness. This becomes suggestive of the assumption that it cannot be subject to the conditions typical of linear systems.

Since social actors living within a given social environment or setting, reflect features that allow for the development of complexity as against simplicity, then the assumptions under the concepts of linearity do not apply in their case, since the laws guiding the principle of linearity, cannot be the same with those that guide non-linearity. This led to the emergence of complexity theory, whose set of assumptions and concepts are primarily meant to deal with situations of complexity, mostly associated with social systems. Most of the theory's concept borrows from assumptions already established, in their application to scientific enquiries of natural systems.

It is against this background, that this paper sought to, explore and adopt concepts that were once uniquely attributable to the science of complexity in natural sciences, with a view to providing suggestions that could be found useful in analyzing and addressing issues of concern, in the Nigerian Educational System, as a social system that is characterized by complexity, in the light of sustainability. The paper is divided into six sections. It starts with a brief abstract, and then followed by the introduction. The clarification of key term follows; we then examine the current challenges of the educational system and explore the complexity approach in the section that follows. In the next section, attempt to conceptualize complexity in the light of the education system will be made and practical implication of complexity theory will be suggested, as the paper ends with suggestive recommendations.

38.2   Conceptual Clarification of Key Terms

For the prevailing purpose, the paper discusses the following key terms with a view to situating the same in the context of intellectual argument building. At the end, a combination of their effects is expected to condition the mind of the reader to understanding the implication of the terms in explaining the connection between complexity theory and the future of education in Nigeria.

38.3   Complexity Theory

Complex adaptive systems are mostly non-linear feedback network, operating far from equilibrium, and natural and human systems have been described as such. According to Jacobson and Wilensky [6], chaos and complexity are characteristics of social systems and are triggered by the evolutionary and revolutionary changes taking place in their environment. As such, fluctuations and disturbances such as technological innovation, changing legal rules and governmental regulation force organizations or social systems to live with chaos or complexity. Complexity theory thus describes the behavior of complex human, social and natural systems in the long run.

38.4   Sustainable Education and Educational System

A change of educational culture is one which develops and embodies the theory of sustainability in a way which is critically aware. It is therefore a transformative paradigm which values, sustains and realizes human potential in relation to the need to attain and sustain social, economic and ecological well being, recognizing that they must be a part of the same dynamic [20]. There is an inherent system oriented approach in this definition that sees sustainability in the educational sense, as rather holistic and relationally consistent. The dominant paradigm of any educational system of a given society should be able to meet the transformative needs of that society, especially as it relates to sustainability. They went on, to comment the nature of the dominant paradigm of most educational system, gave a clear distinction between two opposing orientation of the system. They argue that vocationally oriented systems seem to focus more on the preparation of students to fit into particular places in the labor market. On the other hand, academically oriented systems tend towards bringing as large a proportion of students, to as high a level of general ability possible. These two orientations, though still valid, portray a picture, that is consistent with the dominant feature of most educational systems, where emphasis on qualification and socialization flourish at the expense of transformative needs of society.

An important distinction, central to the question of sustainability however, views educational values as having two distinct orientations, namely intrinsic and instrumental educational values. The latter tend to stress purpose, and product, in other words its emphasis is on outcomes and effectiveness. It is concerned more with "what education is for" rather than the nature of education. While the former, stresses process, in other words, the quality of experience of teaching and learning and is primarily concerned with "What education is" rather than what it might eventually lead to, or influence [20]. While both vocational and academic orientations of education remain valid, an educational system that promises sustainability is

one that requires an integrative and relational thinking and action, while still being accommodative of synergy between the intrinsic and instrumental values.

38.5   Nigerian Education System: The Current Challenge

Based on the foregoing, it is important to state at this point, that, the analysis of the educational system in Nigeria in relation to the current challenges intended in this section of the paper, is limited in scope, to the extent that the study satisfies inquiry into the central issues of the system's characteristics and the accompanied perceived, or actual dysfunctional nature, of the system as a whole. This would be, with a view to understanding its governing dynamics, as social system and by implication, a complex system. Technical structural patterns and administrative issues as well as other components of the system across dimensions, will therefore be treated as they blend in the larger holistic framework of the system, for our purpose. This implies therefore, that the emphasis of the analysis would be in the light of systematic relationship of all its varying components, rather than in depth comprehensive account, of the multidimensional structural pattern and the relationship that characterize the system.

38.6   The System Failure

Peters [12] outlined four types of failure: Objectives not met, inappropriate objective, undesirable side effects, and designed failure. Considering the prevailing situation all of these types of failure, are contextually traceable in the Nigerian educational system. Moja [8] listed, some of the problems that are suggestive of the current state of the system.

1. Lack of adequate infrastructure
2. Lack of well-trained human resources
3. Issues of access and equity in the system
4. Deterioration of quality
5. Inadequate funding mechanism
6. Ineffective curriculum
7. Admission and examination malpractice

The above stated problems, even though obvious and reflective of the apparent system failure of the educational sector, are in reality descriptive of the symptoms that point to, even a more complex problem, inhibitive of the system, when viewed holistically from the systems perspective.

The diagrammatical illustration in Fig. 38.1, attached to this paper, is a representation of the complexity that characterizes the system, and the resulting system failure, when viewed through the lens of complexity sciences. The starting point
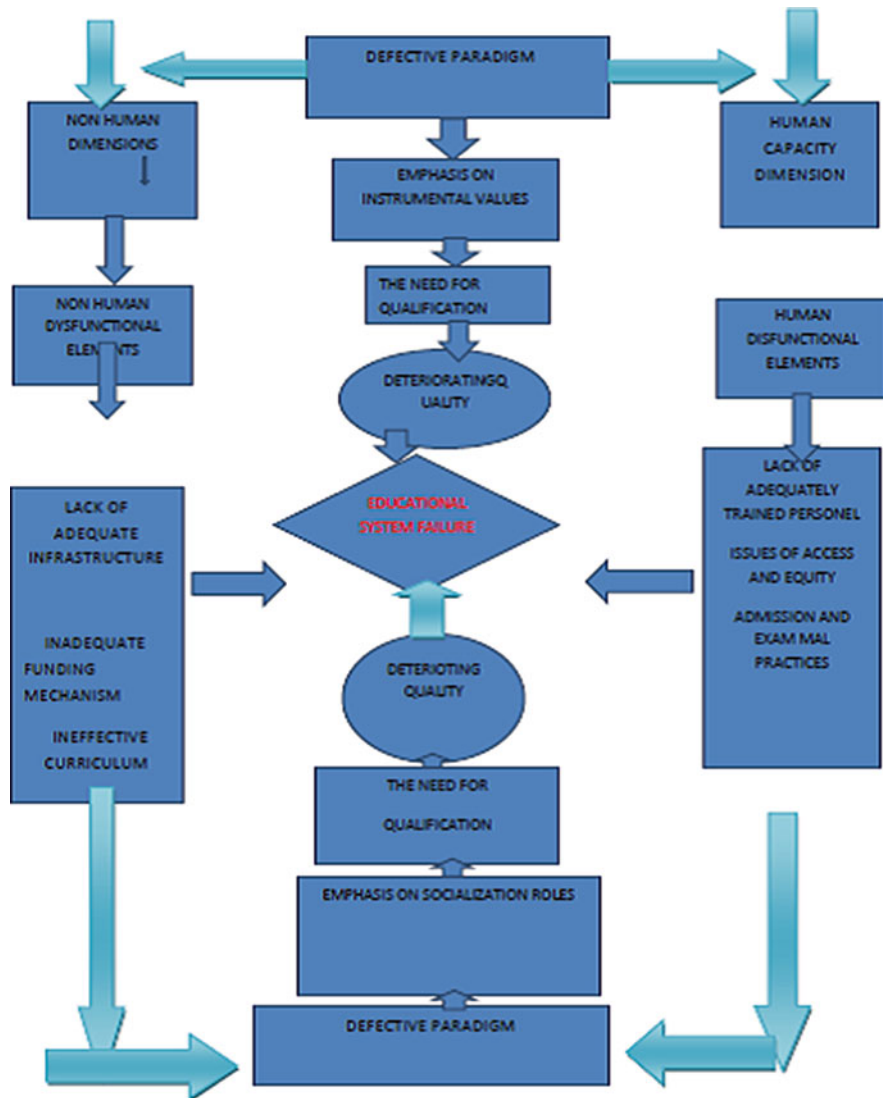
Fig. 38.1 Diagrammatical illustration of system failure (Source: The author)

of the problem as shown, lies in the defective paradigm, held by the interactive actors involved, within and outside, the complex environment where they exist and the nature of the complexity, that binds them as a system. This so called, defective paradigm, which is based on instrumental values, and which promotes a strong emphasis on paper qualification, do so, at the expense of the much needed quality learning, central to a functionally viable and operational system. The nature of interactions, due to systematic connectivity and the resulting interdependence,

across dimensions and between various elements, that characterize the overall educational system, is consequential to the failure of the overall system and can best be appreciated, with increased understanding of the complexity approach that informed this very interpretation.

38.7   The Complexity Approach

The science of complexity is based upon three sets of concepts that are critical to our understanding of educational systems as phenomena in social systems. These sets of concepts, as elaborated by Ramalingam [13] represent a condensation of ten other concepts that are indispensable to the science of complexity. A close examination of the concepts, most relevant, to the current discourse, will be briefly made as presented by these authors. In their categorization of the three sets of key concepts, mostly used in the complexity sciences, Ramalingam [13] associated complexity with three other related concepts, namely; System, Change and Agency, all of which provide the basis for the applicability of the general concept, to varying situations, that are reflective of the resultant three dimensions. The three sets of complexity science concepts across these dimensions are as follows:

1. Complexity and Systems
2. Complexity and Change
3. Complexity and Agency

They listed under each of these three set of concepts, other concepts uniquely attributable to them, and all of them can provide useful insights and aid our understanding of the subject matter. The description of the concepts listed under, the first general concept will provide justifications for considering the Nigerian education system as complex system, while concepts listed, under the other two broader concepts will prove useful, when attempt would be made, to suggesting the attainability and viability of Sustainable education, as desirable end.

38.8   Complexity and System

According to Ramalingam [13], three major concepts are descriptive of a complex system; Namely: Interconnectedness and interdependence of elements or dimensions within and outside the system; feedback processes; and emergence.

Interconnection and interdependence of elements and dimensions: Nicolis and Prigogine [10] described a complex system as one made up of multiple elements (which may also be processes) which are connected to and are interdependent on each other and their environment. This implies that, Interdependence comes into being, when interconnection is firmly rooted between elements and dimensions. Commenting on the nature of such relationship in relation to diverse variables,

[22] asserts that interconnectedness may occur between individual elements of a system, between sub-systems, among subsystems, between different levels of a system, between systems and environment, between ideas, between actions, and between intentions and actions This, according to Ramalingam et al. [14] gives rise to interdependence between the elements and the dimensions of a system and gives rise to complex phenomena.

Feedback process: In a broad sense, feedback can be described as an influence or message that conveys information about the outcome of a process or activity back to its source [2]. The nature of feedback is such that, as Jarvis [7] captures it, can amplify or effect positive change, in a particular direction or of a particular kind, leading to reinforcing pressures, which can lead to escalating change in the system. By implication, feedback can also effect the other way round, such that the change, triggers forces, that counteract the initial change and return the system to the starting point, to decrease deviation from the system [14]. In complex systems, as Byrne [1] suggests, feedback is about the consequence of non linear, random change over time.

Emergence: The concept of emergence describes how overall properties of a complex system emerge from interconnections and interaction. While the nature of the entities, interactions and environment of a system are key contributors to emergence, there is no simple relationship between them. Emergence has been used to describe features such as social structure, human, human personalities, the internet, consciousness and even life itself. As one lucid account has it [9]. In complex systems, it is the interactions of the individual components, that give rise to the emergence of some kind of property which could not have been predicted from what is known of the components parts . . . . . . emergent behavior, feeds back, to influence the behaviors of the individuals that produced it (Langton, cited in [21])

38.9   Complexity and Change

Four concepts relate to different aspects of how complex systems, change overtime. This includes: Non-linearity; Sensitivity of complex systems to their starting conditions; the idea of phase space; Chaos within complex systems.

Non-linearity: Complexity science suggests, that human systems, do not work in a simpler linear fashion. Feedback processes between interconnected elements and dimensions lead to relationships that see change that is dynamic, nonlinear and unpredictable [18]. Therefore non-linearity is a direct result of the mutual inter-dependence between dimensions found in complex systems. In such systems, clear causal relations, cannot be traced because of multiple influences [14]

Sensitivity to initial conditions: This idea stresses the importance of history in complex systems, in that it recognizes its impact in the evolutionary process of a given systems as it moves to a different state over time. The concept of phase

space (Which we shall discuss later) is much related to this idea. Phase space allows for the analysis of the evolution of systems by considering the evolution as a sequence of states in time [15]. What this implies is that, future interactions of a given complex system are being influenced by past historical processes.

Phase space: The dimension of any system can be mapped using a concept called phase space, also described as the "space of the possible" [17]. As Ramalingam et al. [14] suggests, attempting to understand the system (complex system) should start by identifying the key dimensions, then track changes in them, using it to develop a holistic picture of how the system changes and evolves. This represents the basic idea, central to the concept of phase space.

Chaos within complex systems: Chapman [3] in connection to this concept asserts that societies and all its institutions are in continuing process of transformation and that emphasis should be placed on guiding, influencing, and managing these transformations. This implies, learning to operate at the edge of chaos, which in turn encourages the acknowledgment of continues change in social systems in other words, complex systems.

38.10 Complexity and Agency

The set of concepts inclusive in this set, are: Adaptive agents; Self organized behavior; Co-evolution Stacey [19]

Adaptive agents: All living things are adaptive agents, individual people are adaptive agents, so are teams in which they work, and so are organizations. Complex systems are said to be adaptive or evolving, when individual agents, respond to forces in their environment via feedback. Regardless of size and nature, adaptive agents share certain characteristics, in that they react to the environment in different ways [5]. The ability of adaptive agents to perceive the system around them and act on these perceptions, means that, their view of the world, dynamically influences, and is influenced by, events and changes within the system [14].

Self-organization: The concept of self-organization, echoes emergent properties, and the fact that complex system, cannot be understood as the sum of its part, since it may not be discernable from the properties of the individual agents and how they may behave in large numbers. [16]. The key central idea of this concept projects the assumption that change, order, and resilience cannot be imposed from the outside or from the top down, but that these can be achieved through the adaptive tendencies of individual agents operating throughout the system. [14].

Co-evolution: This reflects the idea, that in complex systems, large-scale process through which the interaction of one or more co-evolved species with the system, results in changes so fundamental that all species in the system must and the system itself changes.

In the foregoing, a brief explanation, of the basic critical concepts, that are central to an understanding of complexity sciences has been made. The basis of which, will serve the exploratory and prescriptive objective of this paper. What follows is a logical attempt to harmonize these concepts in favor of our intent of conceptualizing Nigerian educational system as complex adaptive system, to lay the foundation of our subsequent analysis.

38.11   The Complexity of the Nigerian Education System as Adopted

In this section, attempt is made to logically harmonize all the concepts that define complexity as outlined above, in a way that fits the main assumptions of the concepts, and into the fabric of the Nigerian educational system. This is, with a view to providing a logical frame work for deductions that will eventually justify, in the final analysis, the suggestive implication of complexity theory and its applicability towards educational sustainability in Nigeria, which is the main objective of this paper.

38.12   The Education System as a Complex System

The Nigerian educational system emerged overtime, and is revealing of an inherent *interconnection and interdependence* that resonate around relationship between elements and around variables and processes from varying dimensions. From the government and administrative dimension, the system reveals high level of this *connectivity* starting from the Federal ministry of education. The ministry through various series of *activity and feedback* processes interacts with other elements along different dimensions under a unifying framework, for the purpose of coherence. This, it does, while ensuring that, through the coordination of National council of education and the advisory function of joint consultative committee on education, national policies and procedures, remain consistent with national objectives, in all states across the country [17].

Secondly, since human systems along with their varying attitudinal inclinations and preferences, represent *nonlinear* manifestations of interactive processes within and outside of their environment, transformative experiences *draw from past experiences* and are filtered through the lens of *familiar conditions*, thereby facilitating change during *chaotic* circumstances, for proper adaptation. The rapid growth of the educational system in the late seventies and early eighties was mainly in size and not quality. This problems of expansion that was highly disproportionate to the supposedly supportive intent of the then, policy implementation processes, has been a re-occurring theme, in subsequent transformative periods in the light of deliberate efforts by the government towards sanitizing the system.

Lack of planning capacity and management amongst various interplays of relational efforts at various levels and periods, seem to reflect *previous tendencies* as response to new changes [11].

The forgoing, thus illustrate, from the examples cited, the running complexity in the Nigerian educational system, by being indicative of how it resonates, with the features, embodied in the first two sets of the general concepts that define complexity, in relation to firstly; "system" and then "change" as outlined above. This provides the basis for referring to it, as: complex system.

38.13   The Educational System as Complex Adaptive System

Drawing from the foregoing deduction, as evidenced through conceptual association of the educational system of Nigeria with the tenets of the complexity sciences, a further justification of the complexity of the educational system, is the simple fact that it embodies the activity of human social interaction in social settings of varying nature, and varying dimensions that reflect a holistic sense, of *connectivity, interrelatedness* and *interdependence.* As such, it clearly manifests the possible interplay of *evolving adaptive agents* at various levels of social *interactions.* According to Ramalingam et al. [14] Complex systems made up of adaptive agents are distinguished by the term; "Complex Adaptive System" If the existence of adaptive agents within a complex system, confirms the status of such a system as Complex Adaptive System, then it follows that, such a confirmation, by virtue of the complex nature of the Nigerian educational System with its interplay of adaptive agents resonates with the description of the system as Complex Adaptive System.

38.14   Implication for Application of the (CAS) Concept to the Nigerian Education System

The need to change education paradigm, in the context of sustainability, argued Sterling [20], becomes essential, if *co evolution* towards sustainable life style is held with great importance. In his view this change in paradigm involves a change in educational culture towards transformative paradigm that values, sustains and realizes human potential. What this implies is the development of a strong will capable of affecting such a cultural shift towards desirable ends. To this end, such a will must be internally generated and must be consistent with the right kind of motivation. In other words the will must be intrinsic and ignited by a value adding motive or motives. Complex Adaptive systems that consist of adaptive agents inspired by this kind of perception are likely instrumental agents of change, when faced with situations that requires a will to change for the better. As, such, different individuals and organizations within a problem domain will have significantly

different perspective, based on different histories, cultures and goals. These different perspectives have to be integrated and accommodated if effective action is to be taken by all relevant agents [3].

This concept can thus, be contextualized in a way and manner that seem consistent with the educational needs of Nigeria, and the leadership challenge that inhibits its progress towards sustainable development. This is because; the issue of leadership cannot be divorced from the scope of this current discourse by virtue of its instrumental essence towards effective transformation of any kind.

It is on the basis of these broad assumptions that the paper puts forward the following prescriptive suggestions, hoping they ignite, the right kind of curiosity, that make, their practical applicability possible, as derivatives of the foregoing analysis centered around complexity theory and sustainability and as conclusions and recommendations, derived there from. The prescriptive assumptions are also diagrammatically captured and presented in the Fig. 38.2.

38.15   Conclusion and Recommendations

Going by all that have been put across via the foregoing paragraphs, the following observations are conclusively consistent with insights derived from the analysis of all the reviewed literature thus:

The fact that educational system is a social system and thus complex, makes it receptive to the idea of Complex Adaptive System and accompanied by corresponding possible (practical) applicability.

1. The adaptive agents that characterize Complex adaptive system, through effective manipulation of their internal circle of concern, can develop and enlarge their external circle of influence, to a point of systematic self organized co-evolution, which is contagious.
2. This could lead to intrinsic processes, capable of inspiring cultural shift that defines a new set of paradigm that could be an effective tool, to be used for positive transformation that is necessarily supportive of purposeful leadership and is being supported by an effective political ideology which in turn supports prosperous economy.
3. The presence of good political ideology and the absence of poor economy will facilitate the development of effective, adaptive agency from the followers' dimension that is responsive to the contagious nature of the adaptive agents at the upper dimension. This inspires the development of paradigm shift that is intrinsically oriented towards positive transformation
4. Emphasis will now shift towards the quest, for a kind of knowledge, that is value adding, to individual adaptive agents that share common, positive, natural disposition, inspired by the common quest towards this need for positive transformation, across dimensions.
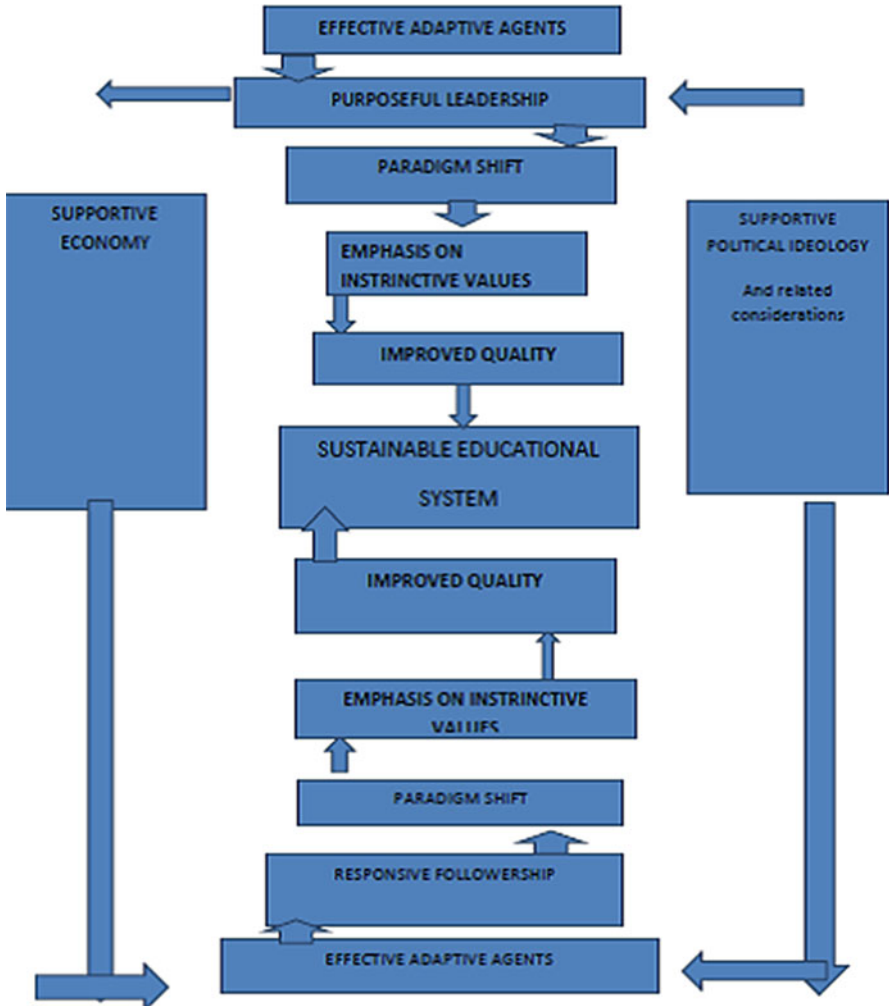
Fig. 38.2 Diagrammatical illustration of sustainable education from the point of view of complex adaptive system (Source: The author)

5. Natural positive results will become manifest in form of increased understanding of qualitative nature in all inclusive ramifications of knowledge, which through its value adding capacity broadens the intellectual horizons of adaptive agents in an emergent self organized revolutionary transformation of thought pattern, which in turn affects behavior and guides it, towards praise worthy tendency and away from behavior that discourages blame worthy dispositions

6. The continuous nature of this behavior over time, generates more number of such adaptive agents and through co evolving nature of interactive complexity, a general pattern of conformity spreads across dimensions and re enforces the need

for quality knowledge, in a rather, progressive fashion This becomes consistent with the perpetual activities of the system, while reinforcing the conditions that sustain the system in that direction towards transformation

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