APPLICATION OF TRIZ FOR DEVELOPMENT OF A SUSTAINABLE EDUCATION SYSTEM

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Abstract

It has been established that man-made systems follow certain patterns from birth to demise that are highly predictable. The different stages can be identified and predicted by application of the so-called eight Evolution Patterns. The Evolution Patterns are informative by describing what is happening to the system, prognostic in predicting the direction in which a given system evolves, and of strategic value in helping to find solutions to complex problems in a well-thought-out manner.

The objective of the paper is to illustrate how different reasoning styles resulting from application of the patterns of evolution can enhance the sustainability of systems such as an educational system.

The methodology on how to apply the unique evolving and predictable nature of the eight observable patterns to find lasting solutions for ageing systems is described and applied to the South African education system.

A number of possible redesign solutions for the current South African education problem are identified, confirming the strategic value of finding sustainable solutions to complex problems by applying the Evolution Patterns in a systematic manner.

The novelty of the paper lies in the described symbiosis between the system evolution patterns, different reasoning styles, and functional drivers that will sustain lasting solutions for education systems.

Keywords: evolution patterns, sustainable systems, system drivers, education system, South Africa.

1 INTRODUCTION

The theory of inventive problem solving (TRIZ) \cite{1, 2} offers a comprehensive set of tools to analyse and solve problems from different perspectives \cite{3}. Perhaps the most promising of the available TRIZ tools are the application of the trends and patterns of evolution that occur during the life-times of systems. All man-made systems become ineffective, inefficient, and/or insufficient over time. Application of these evolution patterns enables the development of sustainable systems at a lower risk of becoming outdated \cite{4, 5}.

The process consists of the following steps:

- Defining the current state of the problematic system for each of the eight evolution patterns.
- Brainstorming possible evolution opportunities on how to achieve the Ideal Final Result (IFR).
- Brainstorming each system driver separately to find solutions to the physical, energy, and information problems.

The current South African education system will be used in this paper to demonstrate the methodology to be followed.

2 METHODOLOGY

The methodology is being applied has been refined through management consulting experience gained over more than a decade in the training in and application of TRIZ knowledge, methodologies and practices to ageing and problematic systems in South African mining, manufacturing, and commercial industries, as well as by teaching the specific process to members of a South African Engineering Institute.

The uniqueness of the process described in the paper is that it applies the fundamental three drivers (material, energy, and information) in problematic systems as a brainstorming tool within the predictable eight Evolution Patterns in a systematic manner, in order to identify strategic answers to which aspects should be addressed to find more sustainable solutions.
The paper describes the unique process to be followed. It is applied to the South African educational system as an example only, to illustrate the process. Identification of the actual evolution patterns and the resultant opportunities and possible solutions is the result of interactive brainstorming by the authors.

The following diagram depicts the three steps that will direct the mind in a structured manner towards sustainable solutions for complex problems.

![Diagram of steps](image)

**Figure 1. Summary of steps to derive sustainable solutions.**

The necessity of shifting from deductive to inductive reasoning is to enable a microscopic focus on existing problems, and then a telescopic expansion of the mind to visualize ideal expectations. Starting from an observation or set of observations, abductive reasoning is a form of logical inference that seeks to find the simplest and most likely explanation for the observations. This process, unlike deductive reasoning, yields a plausible conclusion but does not positively verify it. Abductive reasoning is necessary to extract a variety of possible opportunities from the Evolution Patterns that could offer sustainable solutions towards the defined Ideal Final Result (IFR).

### 3 RESULTS

#### 3.1 Step 1: Defining the problem and problematic system drivers

Deductive reasoning is required to define the problem in concise terms and the problematic system that needs to be rectified. Then the physical, energy, and information system-drivers of the problem should be defined, indicating if they are insufficient, excessive, or harmful.

![Diagram of input and output drivers](image)

**Figure 2. Illustration of input and output drivers in a problematic system**

**Application:** The problem is how to ensure high educational standards in the current South African national education system that is at present failing to provide adequate and effective governing and delivery infrastructures.
The problematic drivers of the current South African National Educational System are:

- Physical/Material drivers: Inadequate and ineffective governing and delivery infrastructures.
- Energy drivers: Excessive citizen demands for free education.
- Information drivers: Dropping curricula standards.

3.2 Step 2: Defining the IFR (the ideal final result) and the system drivers

Conventional deductive reasoning to find solutions for the problem is constrained by the present obstacles. Reasoning inductively from where you want to be, the Ideal Final Result, increases the number of potential solutions as the mind seeks possible solutions. Working backwards from where you want to be to where you are, removes the principal obstructions between where you are and where you want to be.

![Figure 3. Illustration of working backwards from the Ideal Final Result (IFR) to the problem](image)

Also note that reasoning from the problem invokes probability thinking that constrains creative thinking. Reasoning from the IFR backwards invokes possibility thinking that stimulates unconstrained creative thinking.

Defining the ideal system drivers (physical, energy, information) for the IFR is required to serve as beacons towards which the mind must stretch when brainstorming the Evolution Patterns for solutions.

**Application:** The IFR is sufficient, effective and efficient education and training for all South African citizens.

The ideal system drivers are:

- Physical: Sufficient, effective, and efficient governing and delivery educational infrastructures.
- Energy: Educational access for all SA citizens.
- Information: World leading education and training curricula.

3.3 Step 3: Identifying Evolution Pattern opportunities and defining conceptual solutions

Man-made systems follow certain patterns from birth to demise that are highly predictable, the different stages of which can be identified and predicted. The Evolution Patterns are informative by describing what is happening to the system, prognostic in predicting the direction in which a given system evolves, and of strategic value in helping to find solutions to complex problems in a well-thought-out manner.

The eight Evolution Patterns of man-made systems [5, p.7] are:

1. Technology follows a life cycle of birth, growth, maturity, and decline.
2. Decreasing human involvement with increasing automation.
3. Transition from macro systems to micro systems.
4. Increasing complexity, followed by simplicity.
5. Increasing dynamism and controllability.
6. Uneven development of subsystems.
7. Matching and mismatching subsystems.
8. Evolution towards Ideality.
The Eight Evolution Patterns can be applied to the South African Educational System in the following way:

**Evolution Pattern 1: Systems follow a life cycle of birth, growth, maturity, and decline (the S-curve)**

The current SA national education system is in decline caused by mismanagement and corruption. Evolution opportunities are:

- Physical drivers: Prosecuting corrupt and replacing incompetent management to stop further decline.
- Energy drivers: Developing and introducing an educational system that fits the SA population profile.
- Information drivers: Enforcing curricula standards by law.

**Evolution Pattern 2: Decreasing human involvement with increasing automation (the law of energy conservation)**

The current SA national education system is burdened with excessive unqualified employees due to nepotism, and the policies for job-creation. Evolution opportunities are:

- Physical drivers: Automation and integration of management systems.
- Energy drivers: Offering free virtual education and training to the underprivileged.
- Information drivers: Introducing accredited virtual education and training.

**Evolution Pattern 3: Transition from macro systems to micro systems (through the use of fields and modularization)**

The current SA national education system is burdened by overpopulated schools and universities. Evolution opportunities are:

- Physical drivers: Breaking large complex management systems into logical modules that can be automated.
- Energy drivers: Providing free online or downloadable educational and occupational training material.
- Information drivers: Accrediting free online or downloadable educational and occupational training material to maintain high standards.

**Evolution Pattern 4: Increasing complexity, followed by simplicity (through integration)**

The current SA national education system consists mainly of ineffective government controlled systems. Evolution opportunities are:

- Physical drivers: Closing ‘job creation’ and ‘nepotistic’ driven infrastructures and focusing only on educational needs.
- Energy drivers: Simplifying elementary training by integrating it with private and industrial apprenticeship programs.
- Information drivers: Accrediting elementary and collaborative education and training programs.

**Evolution Pattern 5: Increasing dynamism and controllability (through harmonizing of parts of a system)**

The current SA national education system is in total disharmony caused by internal mismanagement and corruption. Evolution opportunities are:

- Physical drivers: Enforcing clear educational objectives with a ‘no-tolerance’ policies for mismanagement and corruption.
- Energy drivers: Promoting industry driven bursaries and loans for tertiary training.
• Information drivers: Aligning academic and industry training standards.

**Evolution Pattern 6: Uneven development of subsystems (resulting in contradictions)**

The current SA national education system has contradicting and uneven silo organizations characterised by self-interest and corrupt government and private practices.

Evolution opportunities are:

• Physical drivers: Separating academic/professional and apprenticeship/occupational training infrastructures, e.g. Universities and Technikons.
• Energy drivers: Providing separate training lanes for academic/professional and apprenticeship/occupational training.
• Information drivers: Differentiating between educational and occupational training.

**Evolution Pattern 7: Matching and mismatching subsystems (law of system completeness)**

The current SA national education system does not match education and training outcomes to the SA professional and labour needs.

• Physical drivers: Separating academic/professional and apprenticeship/occupational training infrastructures, e.g. University and Technikon.
• Energy drivers: Providing separate training lanes for academic/professional and apprenticeship/occupational training.
• Information drivers: Differentiating between educational and occupational training.

**Evolution Pattern 8: Evolution towards Ideality (increased beneficial and decreased non-beneficial features)**

The current South African national education system focuses more on political goals than on educational needs.

Evolution opportunities are:

• Physical drivers: Eliminating the influence of trade unions on schools and focus on educational delivery needs.
• Energy drivers: Moving towards free virtual education and training.
• Information drivers: Updating curricula standards in line with the world’s best.

3.4 **Identify sustainable solutions**

The last step is to extract the main themes from all the identified opportunities above using the Affinity Diagram mind leveraging tool. Affinity diagramming is a technique used to externalize, make sense of, and organize large amounts of unstructured, far-ranging, and seemingly dissimilar qualitative data [6]. It is a tool that gathers large amounts of language data (ideas, opinions, issues) and organizes them into groupings based on their natural relationships. The Affinity process is often used to group ideas generated by Brainstorming.

**Application:** Using the Affinity Diagram mind leveraging tool, the following conceptual solutions for the SA national education problem were identified by extracting the main themes from the above opportunities:

• Developing and introducing an educational system that fits the SA population profile.
• Enforcing clear educational objectives with a ‘no-tolerance’ policies for mismanagement and corruption.
• Investigating and replacing corrupt officials and unqualified employees.
• Providing separate training lanes for academic/professional and apprenticeship/occupational training.
• Collaborating with private industry to accredit their apprentice training programs.
• Aligning academic and industry training standards.
• Introducing virtual educational and training systems.
• Enforcing curricula standards by law.
• Automating and integrating current effective educational systems to reduce human involvement.

4 CONCLUSIONS

The methodology set out above has highlighted the fact that finding sustainable solutions for complex problems is not a matter of extracting solutions by just applying the normal practice of deductive reasoning. It has been indicated that application of the so-called eight Evolution Patterns are of strategic value in helping to find solutions to complex problems in a well-thought-out manner.

The pillars to find sustainable solutions to complex problems are the application of deductive, inductive and abductive thinking skills to identify the System Drivers, defining the IFR, and brainstorming the respective system drivers towards the IFR for each of the eight Evolution Patterns.

The strategic value of finding sustainable solutions to complex problems by applying the Evolution Patterns in a systematic manner was confirmed by the identification of a number of possible redesign solutions for the current South African education problem.

Replacing complex systems with sustainable systems has many benefits, and to ensure endurance it will be necessary to regularly assess the state of affairs, and repeat this process to identify new evolutionary opportunities when necessary.

REFERENCES