



Pathways to Higher Education Project

Center for Advancement of Postgraduate
Studies and Research in Engineering Sciences,
Faculty of Engineering - Cairo University
(CAPSCU)



Cairo University

Analytical Thinking

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Analytical Thinking

by

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Analytical Thinking

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On behalf of Pathways to Higher Education Management Team in Egypt, the Project Coordinator wishes to extend his thanks and appreciation to the Ford Foundation (FF) for its full support to reform higher education, postgraduate studies and research activities in Egypt. The Management Team extend their special thanks and appreciation to Dr. Bassma Kodmani, Senior Project Officer at the Ford Foundation office in Cairo, who helped initiate this endeavor, and who spared no effort to support the Egyptian overall reform activities, particularly research and quality assurance of the higher education system. Her efforts were culminated by the endorsement to fund our proposal to establish the Egyptian Pathways to Higher Education project by the Ford Foundation Headquarters in New York.

The role of our main partner, the Future Generation Foundation (FGF), during the initial phase of implementation of the Pathways to Higher Education Project is also acknowledged. The elaborate system of training they used in offering their Basic Business Skills Acquisition (BBSA) program was inspiring in developing the advanced training program under Pathways umbrella. This partnership with an NGO reflected a truly successful model of coordination between CAPSCU and FGF, and its continuity is mandatory in support of our young graduates interested in pursuing research activities and/or finding better job opportunities.

The contribution of our partner, The National Council for Women (NCW), is appreciated. It is worth mentioning that the percentage of females graduated from Pathways programs has exceeded 50%, which is in line with FF and NCW general objectives. The second phase of the project will witness a much more forceful contribution from the NCW, particularly when implementing the program on the governorates level as proposed by CAPSCU in a second phase of the program.

We also appreciate the efforts and collaborative attitude of all colleagues from Cairo University, particularly the Faculties of Commerce, Art, Mass Communication, Law, Economics and Political Sciences, and Engineering who contributed to the success of this project.

Finally, thanks and appreciation are also extended to every member of the Center for Advancement of Postgraduate Studies and Research in Engineering Sciences (CAPSCU), Steering Committee members, trainers, supervisors and lecturers who were carefully selected to oversee the successful implementation of this project, as well as to all those who are contributing towards the accomplishment of the project objectives.

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CU Cairo University

FF Ford Foundation

CAPSCU Center for Advancement of Postgraduate Studies and Research in Engineering Sciences, Faculty of Engineering - Cairo University

NCW National Council for Women

FGF Future Generation Foundation

Publisher Introduction

The Faculty of Engineering, Cairo University is a pioneer in the field of learning and continual education and training. The Center for Advancement of Postgraduate Studies and Research in Engineering Sciences, Faculty of Engineering - Cairo University (CAPSCU) is one of the pillars of the scientific research centers in the Faculty of Engineering. CAPSCU was established in 1974 in cooperation with UNIDO and UNESCO organizations of the United Nations. Since 1984, CAPSCU has been operating as a self-financed independent business unit within the overall goals of Cairo University strategy to render its services toward development of society and environment.

CAPSCU provides consultation services for public and private sectors and governmental organizations. The center offers consultation on contractual basis in all engineering disciplines. The expertise of the Faculty professors who represent the pool of consultants to CAPSCU, is supported by the laboratories, computational facilities, library and internet services to assist in conducting technical studies, research and development work, industrial research, continuous education, on-the-job training, feasibility studies, assessment of technical and financial projects, etc.

Pathways to Higher Education (PHE) Project is an international grant that was contracted between Cairo University and Ford Foundation (FF). During ten years, FF plans to invest 280 million dollars to develop human resources in a number of developing countries across the world. In Egypt, the project aims at enhancing university graduates' skills. PHE project is managed by CAPSCU according to the agreement signed in September 22nd, 2002 between Cairo University and Ford Foundation, grant No. 1020 - 1920.

The partners of the project are Future Generation Foundation (FGF), National Council for Women (NCW) and Faculties of Humanities and Social Sciences at Cairo University. A steering committee that includes representatives of these organizations has been formed. Its main tasks are to steer the project, develop project policies and supervise the implementation process.

Following the steps of CAPSCU to spread science and knowledge in order to participate in society development, this training material is published to enrich the Egyptian libraries. The material composes of 20 subjects especially prepared and developed for PHE programs.

Dr. Mohammad M. Megahed
CAPSCU Director
April 2005

Foreword by the Project Management

Pathways to Higher Education, Egypt (PHE) aims at training fresh university graduates in order to enhance their research skills to upgrade their chances in winning national and international postgraduate scholarships as well as obtaining better job.

Pathways steering committee defined the basic skills needed to bridge the gap between capabilities of fresh university graduates and requirements of society and scientific research. These skills are: mental, communication, personal and social, and managerial and team work, in addition to complementary knowledge. Consequently, specialized professors were assigned to prepare and deliver training material aiming at developing the previous skills through three main training programs:

1. Enhancement of Research Skills
2. Training of Trainers
3. Development of Leadership Skills

The activities and training programs offered by the project are numerous. These activities include:

1. Developing training courses to improve graduates' skills
2. Holding general lectures for PHE trainees and the stakeholders
3. Conducting graduation projects towards the training programs

Believing in the importance of spreading science and knowledge, Pathways management team would like to introduce this edition of the training material. The material is thoroughly developed to meet the needs of trainees. There have been previous versions for these course materials; each version was evaluated by trainees, trainers and Project team. The development process of both style and content of the material is continuing while more courses are being prepared.

To further enhance the achievement of the project goals, it is planned to dedicate complete copies of PHE scientific publications to all the libraries of the Egyptian universities and project partners in order to participate in institutional capacity building. Moreover, the training materials will be available online on the PHE website, www.Pathways-Egypt.com.

In the coming phases, the partners and project management team plan to widen project scope to cover graduates of all Egyptian universities. It is also planned that underprivileged distinguished senior undergraduates will be included in the targeted trainees in order to enable their speedy participation in development of society.

Finally, we would like to thank the authors and colleagues who exerted enormous efforts and continuous work to publish this book. Special credit goes to Prof. Fouad Khalaf for playing a major role in the development phases and initiation of this project. We greatly appreciate the efforts of all members of the steering committee of the project.

Dr. Sayed Kaseb

Project Manager

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Chapter 1: Definition of Analytical Thinking

Introduction



1.1 Introduction

This course deals with analytical thinking from two points of view. The first one; consider the analytical thinking as a cognitive process and its relation to four main concepts: Synthetical (Chapter 2), Systemic (Chapter 3) Critical (Chapter 4) and Creative Thinking (Chapter 5).

The second point of view; approach to analytical thinking as a style explaining its main characteristics.

At last some techniques to think analytically such as: decomposable matrices, dimensional analysis, input/output, organized random search, and relevance system are presented.

Figure 1.1 shows a clear formulation of the main components of the text.

1.2 Definition of analytical thinking

Analytical thinking is *a powerful thinking tool - for understanding the parts of situation.*

It is defined as:

- **The ability to scrutinize and break down facts and thoughts** into their strengths and weaknesses.
- **Developing the capacity to think in a thoughtful,** discerning way, to solve problems, analyze data, and recall and use information.

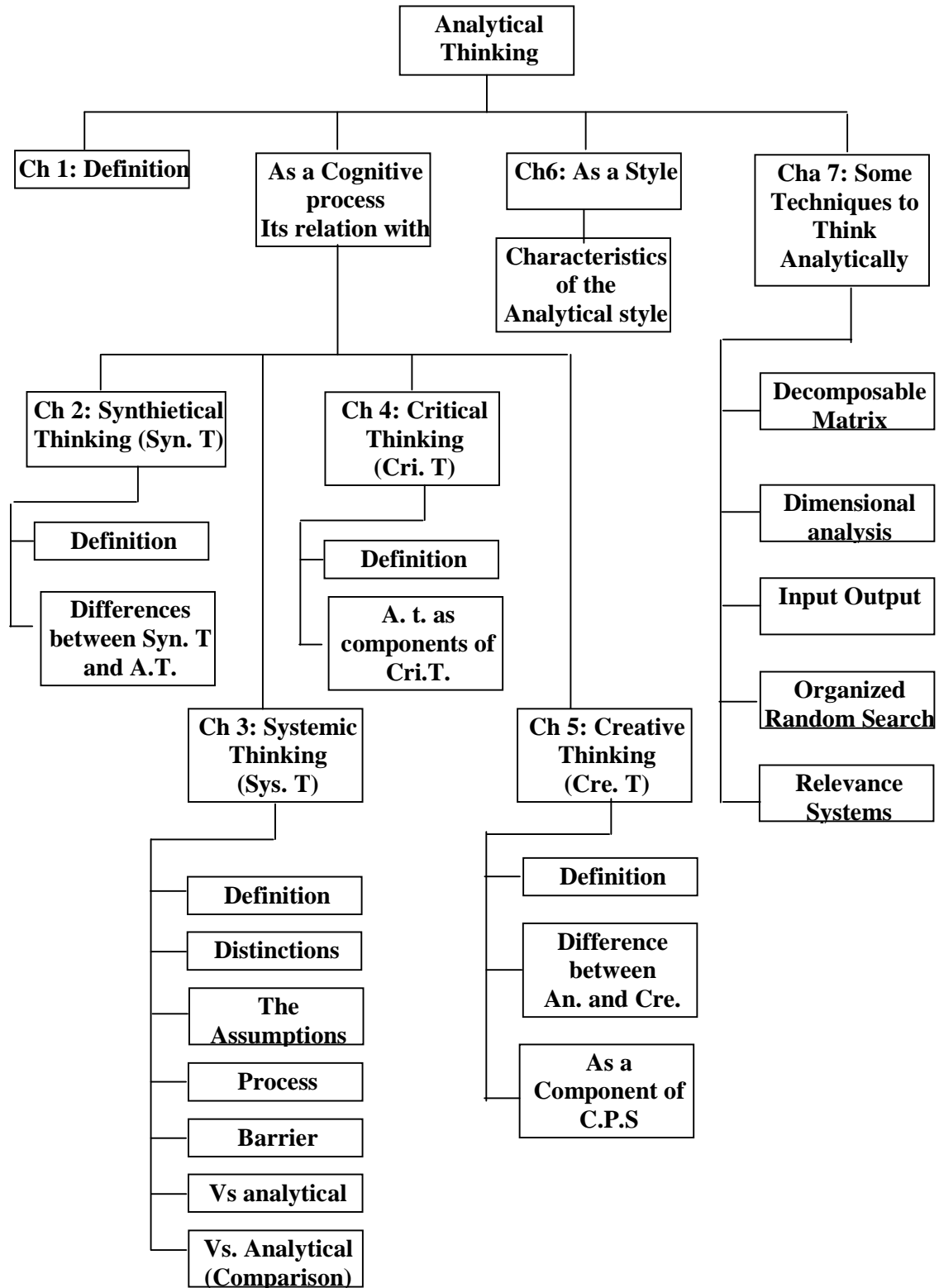
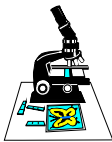


Figure 1.1: Formulation of the main components of the course

Chapter 2: Analytical Thinking vs. Synthetical Thinking

Importance to Use Synthetical Thinking with Analytical Thinking



2.1 Importance to Use Synthetical Thinking with Analytical Thinking

Analysis is a powerful thinking tool - for understanding the parts of a situation. It's just not that crash-hot for understanding how those parts work together.

When we break things down into smaller and smaller components, we tend to lose sight of the interactions between them.

It's a case of **"When the only tool you have is a hammer, every problem begins to look like a nail"** - and we end up with analysis paralysis. Analysis paralysis is when a vicious cycle is set up, as shown in Figure 2.1.

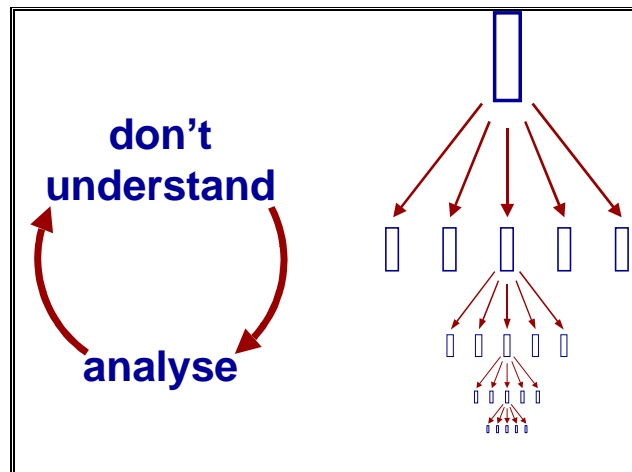
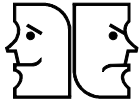


Figure 2.1: Analysis paralysis

Analysis makes the interactions less visible, so insight diminishes, we analyze things further - and things go from bad to worse.

What our society needs is **a thinking tool specifically designed for making sense of Interactions**- a thinking tool for making sense of how things work together. That tool is **synthesis** - seeing how things work together. Synthesis is more than putting things back together again after you've taken them apart: It's understanding how things **work** together.

Difference
between
Analytical
Thinking and
Synthetical
Thinking



2.2 Difference between Analytical Thinking and Synthetical Thinking

According to Bartlett (2001) it can be differentiated between Analytical Thinking and Synthetical Thinking as following:

1. Analytical thinking **enables us to understand the parts of the situation**. Synthetical thinking enables us to understand how they work together.
2. Analytical thinking **breaks things down into their component parts**; synthetical thinking finds the patterns across those component parts.
3. Analysis is about **identifying differences**, **synthesis** is about finding similarities, as shown in Figure 2.2.

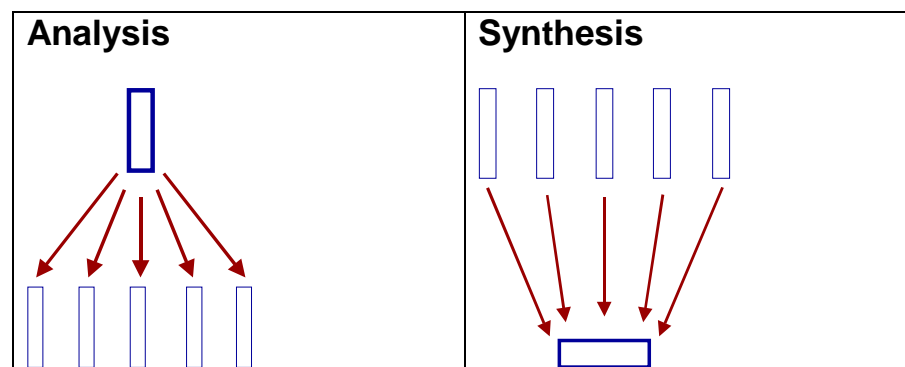


Figure 2.2: Analysis and synthesis

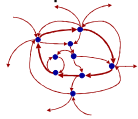
4. Analytical thinking is the easy bit. We've been taught to do it from birth. Synthetical thinking is harder because we haven't been taught to do it deliberately. We do it unconsciously all the time, of course - we wouldn't get very far if we didn't - because everything is systemic and needs to be approached systemically.
5. Synthetical thinking is a lot harder than analytical thinking because the Interactions are harder to deal with and it is dynamic rather than static.
6. Synthetical thinking is deliberately finding repeating patterns (or common themes) across a system or situation. Although analytical thinking enables us to find those repeating patterns and common themes too, it doesn't do so directly - or anywhere near as effectively - because analysis is more focused on identifying differences than similarities.

In sum we need both analysis and synthesis. Each is of only limited value without the other - in a systemic world. Systemic thinking is nothing more than a combination of analytical thinking and synthetical thinking.

Chapter 3: Analytical Thinking as a Component of Systemic Thinking

In this chapter Bartlett's theory about systemic thinking will be represented as he pronounced in the international conference for thinking, (Bartlett, 2001)

Definition of Systemic Thinking and Its importance



3.1 Definition of Systemic Thinking and Its Importance

Systemic thinking is a simple thinking technique for gaining systemic insights into complex situations and problems. It puts the benefits of the systems thinking. *Systemic thinking enables us to deal with the elements of a situation in concert rather than in isolation.* Its power lies in its simplicity and effectiveness. It offers the potential to find systemic focus in any situation. It enables us to secure the dramatic benefits promised by the systems thinking revolution.

Distinctions of Systemic Thinking



3.2 Distinctions of Systemic Thinking.

Systemic thinking is different from both systematic thinking and systems thinking, as shown in Table 3.1.

Table 3.1: Difference between *systemic*, *systematic* and *systems thinking*

Systematic Thinking	Systems Thinking	Systemic Thinking
Thinking methodically.	Thinking about how things interact with one another.	A simple technique for finding system-wide focus.

Fundamental Assumption of Systemic Thinking



3.3 The Fundamental Assumption of Systemic Thinking

The fundamental assumption, on which the systemic thinking concept is based, is that everything is systemic, as shown in Figure 3.1. In other words, everything interacts with (affects and is affected by) the things around it. Everything in which we can't deal with the parts of a situation in isolation; we have to deal with them in concert. We have to

deal with both the elements of a situation **and** how they interact with one another.

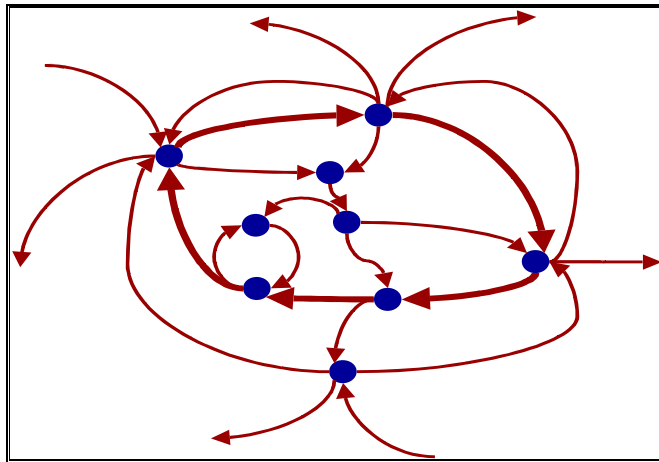


Figure 3.1: Everything is systemic

Systemic thinking is as much about troubleshooting our own mental paradigms as it is about troubleshooting the situations we face.

The Systemic Thinking Process

3.4 The Systemic Thinking Process

The systemic thinking process is very simple:



Step one is to list as many system elements (of the type you're interested) in as you can think of. (e.g. problems, solutions, ideas, opportunities, desired outcomes, needs etc)



Step two is to group similar elements together and describe what each group has in common.



Step three is to find the common theme across (running through) the group descriptions, as shown in Figure 3.2.

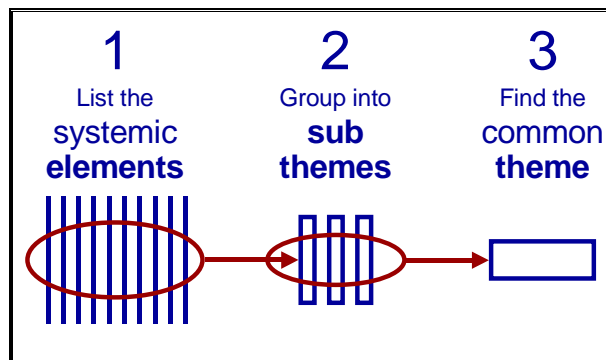


Figure 3.2: The systemic thinking process

The common theme is the systemic pattern across the entire situation - the genius level insight into the entire situation.

Barrier to Systemic Thinking

3.5 Barrier to Systemic Thinking

In a sense, systemic thinking is the reverse of analytical thinking. Analytical thinking breaks things apart in stages- systemic thinking groups things together in stages. **This grouping of things together in stages is the first trick** for dealing with the greatest barrier to systemic thinking- the cognitive dissonance from the conditioned belief that there is no pattern. **A second trick** is to realize that the message from your brain saying "there is no theme and it's pointless looking for one!" is really nothing more than an indication that your brain hasn't found the theme yet.

A third is to develop a library of systemic solutions- they all follow a similar pattern, so once you've seen or developed a few, things get much easier. **Finally**, it's worth noting that progress is better than perfection with systemic thinking. The benefit of the feedback generated when you try a solution -conceptually or for real - is inestimable

The Systemic Thinking as a Combination of Analytical Thinking and Synthetical Thinking



3.6 The Systemic Thinking as a Combination of Analytical Thinking and Synthetical Thinking

The basic idea in systemic thinking is to **list as many different elements as you can think of**, then look for similarities between them. Conventional analytical thinking is different, as shown in Figure 3.3.

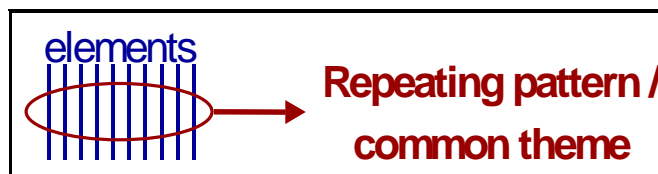


Figure 3.3: The systemic thinking concept

The basic idea in analytical thinking techniques is **to list a handful of elements**, compare them, rank them and then select the most valuable one, discarding the rest. This is all very well, unless the rest of the elements have specific value that the selected one doesn't, as shown in Figure 3.4.



Figure 3.4: The analytical thinking concept

Synthesis needs analysis - how can you find the similarities across different things, if you haven't listed the different things first?

Analysis needs synthesis - understanding how things behave in isolation is pointless. We have to understand how they behave in concert in order to intervene intelligently.

Analysis, in the context of systemic thinking, is different from analysis outside of that context.

Outside of the systemic thinking context, the tendency is to list only a manageable handful of elements, in order to reduce the workload. (Remember that analysis breaks things down into their component parts, so you get more and more things to think about. This creates a tendency to list only a handful of elements). Within the systemic thinking context, it's desirable to list as many different elements as possible, in order to ensure the most representative pattern possible.

Systemic thinking combines analytical thinking and synthesical thinking, as shown in Figure 3.5.

- **The first step** is analytical: list as many elements as you can think of.
- **The second step** is synthesical: find the common theme/repeating pattern across those elements.

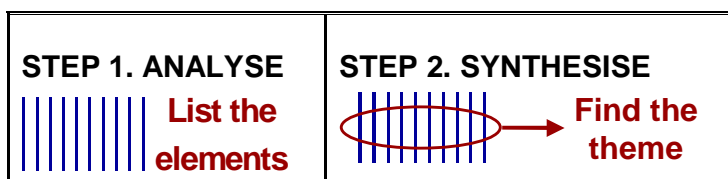
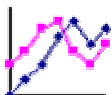


Figure 3.5: The systemic thinking steps

A
Comparison
of Systemic
and Analytical
Thinking



3.7 A Comparison of Systemic and Analytical Thinking

Systemic thinking is the reverse of analytical thinking. Analytical thinking breaks things apart in stages - systemic thinking groups things together in stages. The key differences between the two thinking techniques are:

- **Systemic thinking** lists as many elements as possible (to ensure that the theme is as representative as possible), while **analytical thinking** lists only a handful of elements (to make the workload manageable).
- **Systemic thinking finds and focuses on the theme across the elements**, while **analytical thinking selects and focuses on the most attractive or promising element**, as shown in Figure 3.6.

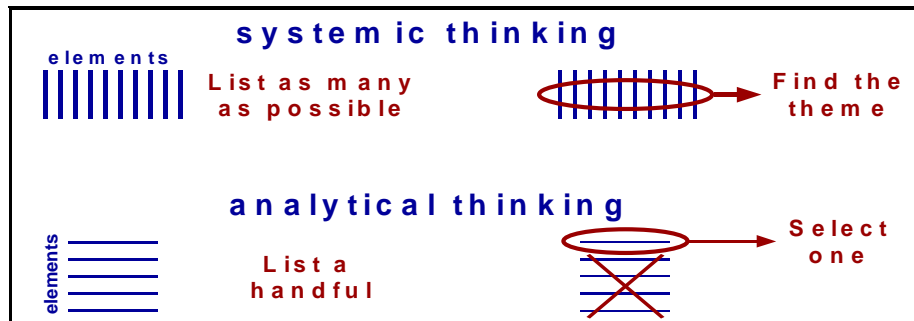


Figure 3.6: Comparison between systemic thinking and analytical thinking

Chapter 4: Analytical Thinking as a Component of Critical Thinking

Definition



4.1 Definition of Critical Thinking

The definition of critical thinking **has changed somewhat over the past decade**. Originally the dominion of cognitive psychologists and philosophers, behaviorally oriented psychologists and content specialists have recently joined the discussion (Huitt, 1998).

The following are some examples of attempts to define critical thinking that include analytical thinking as a component :

- § The critical thinking is *the ability to analyze facts, generate and organize ideas, defend opinions, make comparisons, draw inferences, evaluate arguments and solve problems* (Chance, 1986, p. 6);
- § It is the intellectually *disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by observation, experience, reflection, reasoning, or communication, as a guide to belief and action* (Scriven & Paul, 1992);
- § Involving analytical thinking *for the purpose of evaluating what is read* (Hickey, 1990, p. 175);

Assumption
of Critical
Thinking and
Its
Importance



4.2 Assumption of Critical Thinking and Its Importance

Critical thinking itself **is based on an assumption**. This assumption states that *there is a logic to what you are trying to think about, that it can be figured out and reasoned through*. **Thus, there are some instances where critical thinking may not be appropriate**. For example, **is there logic to romance? Is there logic to matters of personal taste or preference?** It may not be appropriate to spend a great deal of effort analyzing why one likes certain colors, architectural styles, music, art, etc. **But if a situation or decision needs to be figured out or thought through, then a critical thinking approach is needed.**

Critical thinking **allows us to listen to our emotions, without being controlled by them.** "Got feelings" and intuition are often valuable in our decision-making processes. In fact, recent research indicates that some elements of intuition that escape rational analysis may be very important in visual memory and in establishing individual tastes and personal preferences. However, emotions can also mislead us, making us feel that we are right, even when we are not. Critical thinkers do not suppress their feelings nor are they overly influenced by them. The natural response of emotions and feelings can be constructively tempered with critical thinking. Critical thinking provides a way for us to sort through our feelings and emotions to evaluate and identify those most appropriate for a given situation. Thus, critical thinking is not a cold and unfeeling analytical process, but involves emotions and passions, in a positive way. **(Hassel, 1992)**

Chapter 5: Analytical Thinking and Creative Thinking

Definition
of Creative
Thinking



5.1 Definition of Creative Thinking

Creative thinking is **relating/creating of things or ideas which were previously unrelated.**

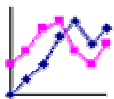
Analytical
Thinking
Assists
Creativity



5.2 Analytical Thinking Assists Creativity

*It is a mistake to see the introduction of systematic thinking as the death of creativity. Certainly there is a danger of the simplicity and elegance of a system becoming more important than actually organizing the event. The analytic approach outlined in this section is an aid to creative thinking. It is often thought that those who have to 'think on their feet' are the creative thinkers. When there is not a well thought out system to assist decision making, then the event management will be continually solving problems, putting out the grass fires. **Problem solving in a state of panic requires a certain amount of creative thinking.** However satisfying this may be when it all works out, it is not substitute for creatively thinking in an ordered and calm environment. Knowing that most problems have been solved before they occur' is a wonderful way to focus on the creative process.*

Difference
between
Analytical
and
Creative
Thinking



5.3 Difference between Analytical Thinking and Creative Thinking

Analytical thinking is logical and leads to unique or few answers, which can be implemented. **Creative thinking** requires imagination, and leads to many possible answers or ideas. While the two sorts of thinking are different, they are linked because one sort complements the other. This is evident in creative thinking, where the many ideas must later be analyzed to sort out the few that can be implemented. Analytical thinking consolidated ideas and practices, and must be followed by creative leaps if progress is to be made.

Analytical thinking is convergent, narrowing down to unique answers or a small number of ideas which can be further analyzed and implemented. **Creative thinking** is divergent, starting from the description of the problem and diverging to give many ideas for solving it, or possible answers to it. In effect, analytical thinking produces solutions and creative thinking produces ideas - large numbers of them from which the solution can be selected. **Convergent and divergent** are appearing more frequently in the literature of creative thinking and in the articles in management papers. The two words are more colorful than analytical

and creative and they do convey a mental picture of the process being followed, as shown in Table 5.1.

Table 5.1: Two sorts of thinking

Convergent	Divergent
<ul style="list-style-type: none"> • Logic • Unique (or few) • Answers • Convergent • Vertical 	<ul style="list-style-type: none"> • Imagination • Many possible • Answers or ideas • Divergent • Lateral

The other two words - **vertical and lateral** - are less well-known but are equally applicable in the context of analytical and creative thinking. Tackling a problem in the analytical way requires deep, and possibly narrow, probing to identify all aspects - hence vertical thinking. On the other hand, creative thinking requires a wide-ranging examination of all the options, including those which might be considered to be wild or foolish, and those which appear to be outside and not linked at all with the problem - hence lateral thinking. Of the two words, lateral thinking is the commoner due to the work on creative thinking by **Doctor Edward de Bono**. The two sorts of thinking can be linked in another way.

In Figure 5.1, **convergent (analytical) and divergent (creative) thinking are illustrated with few solutions and many ideas**. The process can be continued indefinitely, where creative thinking is again used on a solution to generate more ideas. The figure has two misleading features. *The perspectives of analytical and creative suggest that people are better at creative thinking than analytical.* As we shall see, the reverse is true. Secondly there is the deliberate separation of analytical and creative, and this is not representative of real life. Everybody has a creative ability. Unfortunately it is buried within analytical thinking, and this tends to kill the creative ideas too quickly. **"That's silly"** we say, and the idea is discarded. Conscious and deliberate separation is required.

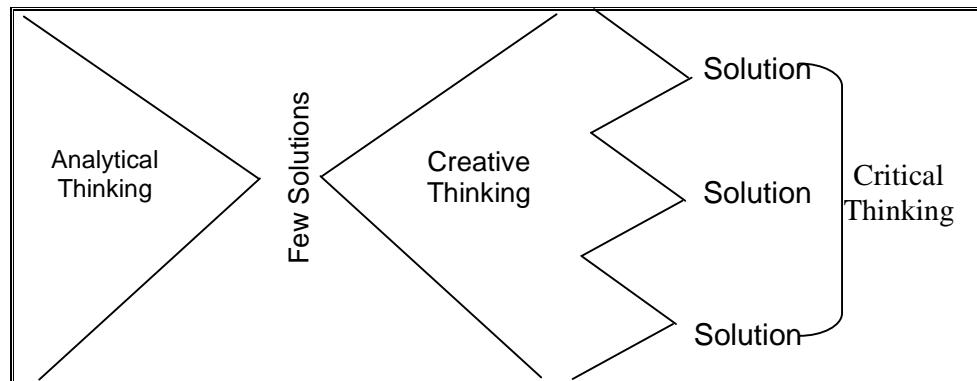


Figure 5.1: Two Sorts of Thinking

Examples
to Explain
the Two
Types of
Thinking



Examples to Explain the Two Types of Thinking

Example 1: Consider this problem

A Scotsman was celebrating his golden wedding anniversary with a family reunion. He had arranged a dinner party in a private room in a local hotel with a piper to welcome his guests on the bagpipes. Shortly after the party started, he looked around the family and noticed that there were present :

1 grandfather	2 sisters
1 grandmother	2 sons
2 fathers	2 daughters
2 mothers	1 father-in-law
4 children	1 mother-in-law
3 grandchildren	1 daughter-in-law
1 brother	

Being a canny Scotsman, he had budgeted carefully, and had the exact money to pay for the party in his sporran. Assuming that the piper was included in the cost of £ 10 per head, how much money did the Scotsman have in his sporran?

A swift glance at the list of guests and adding up the numbers would lead to a figure of £ 230. Not believing that the Scotsman would be so rash as to spend £ 230 on a dinner for his relatives, a second and possibly more suspicious look at the family leads to the realization that some members of the party may have dual roles, i.e. as a father and a son. This leads to a reconsideration of the family and saves the Scotsman a considerable amount of cash.

Apart from a slight feeling of being led up the garden path, or being fooled, the solution to this problem requires logical thinking or counting, and it leads to a unique answer. Because logical thinking or counting is involved, let us define this problem as an analytical problem. (A comment on the size of the Scotsman's family is made at the end of this chapter).



Example 2: Consider now another problem

Suppose you were invited to join a government department on secondment from your organization. You find that the team of civil servants and yourself are considering the problem- **"How to persuade families to take their holidays in Egypt this year?"** This is a different sort of problem from the Scotsman's family. Not just one answer, there are many possible ways of persuading people to take their holidays in Egypt. It does, however, need a certain amount of imagination to overcome the image confronted with glossy brochures showing seaside places in Europe. As imagination is involved, let us define this as a creative problem.



Example 3: As a final example

Imagine you have a piece of 5-ply board, which has three holes cut in it. The holes are triangular, circular and square in shape. You are asked to describe a solid wooden object which will go through each hole, right through and pull clear of the back. When the object is in any hole, it is a tight fit, i.e. the wooden surface touches the 5-ply board at all points of the hole.

At first thought, this seems an impossible object. It is easy to get two out of the three. *For example wooden cone satisfies the circle and triangle, and a pyramid satisfies the triangle and square, but all three seem quite impossible.* **One non-solution is a rod, machined circular at one end, triangular in the centre, and square at the other end.** Unfortunately this object will not pass completely through the board.

The solution requires both creative and analytical thinking: creative in seeing the solid wooden object (in your mind's eye); **analytical** in being able to describe it simple in words. A drawing of the object appears at the end of this chapter. **Looking at this**, it is clear that the three views are obtained by turning the object so as to see it from three different directions at right angles to each other. **"A tent-shaped wedge on a circular base"**, is one description. An even simpler way to describe it is, **"Take a cylinder of wood and cut off the circle and square.** Scribe a line across a diameter, and cut to this line from opposite edges to form a wedge". Notice that the wedge must be tent-shaped, and that two cuts are required. One cut, from one corner to the opposite corner gives a wrong sort of triangle, and will not give the square at all.

This is an example of both creative and analytical thinking, working together. It is, of course, possible to arrive at the shape by analytical thinking only, as most engineers would confirm. In fact I have used this example in many seminars and talks, and am constantly amazed and disheartened by the small number of people who can describe the object. Most people say that it is impossible.

Analytical Thinking as a Component of Creative Problem Solving



5.4 Analytical Thinking as a Component of Creative Problem Solving

The systematic combination of techniques for directed creativity and techniques for analysis continues as a strong theme in several, more recently proposed models. Parnes (1992) and Isaksen and Trefflinger (1985) outline six steps in their popular creative problem solving (CPS) model, as shown in Figure 5.2. (Tens of thousands of people have learned the CPS model and its associated tools through the seminars conducted by the Creative Education Foundation in Buffalo, NY.)

The Creative Problem Solving composed of (CPS) Model, as shown in Figure 5.2.

- Objective finding
- Problem finding
- Solution finding
- Fact finding
- Idea finding
- Acceptance finding

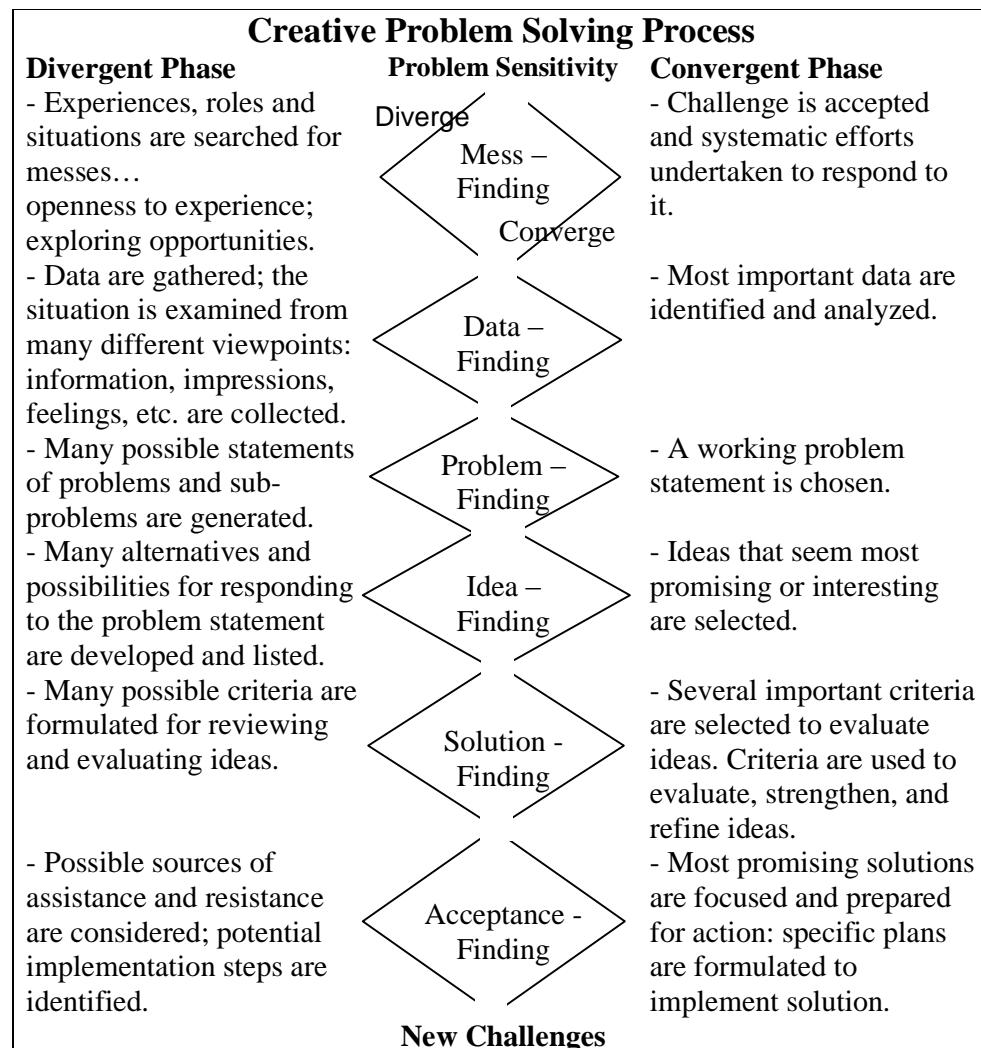


Figure 5.2: Six-Stage Model of CPS (Isaksen and Trefflinger 1985)

Steps 3 and 4 (problem and idea finding) clearly require novel, creative thinking; while steps 1, 2, 5, and 6 require traditional skills and analytical thinking.

Note 1

(Isaksen and Treffinger 1987) changed their description of the **CPS** framework to include these three components of activity as well as the six stages. The components titles Understanding the Problem, Generating Ideas and Planning for Action were added to the framework to clarify that the framework could be used flexibly as components. As indicated in Figure 5.3, they also modified the graphic to more clearly distinguish the components from one another.

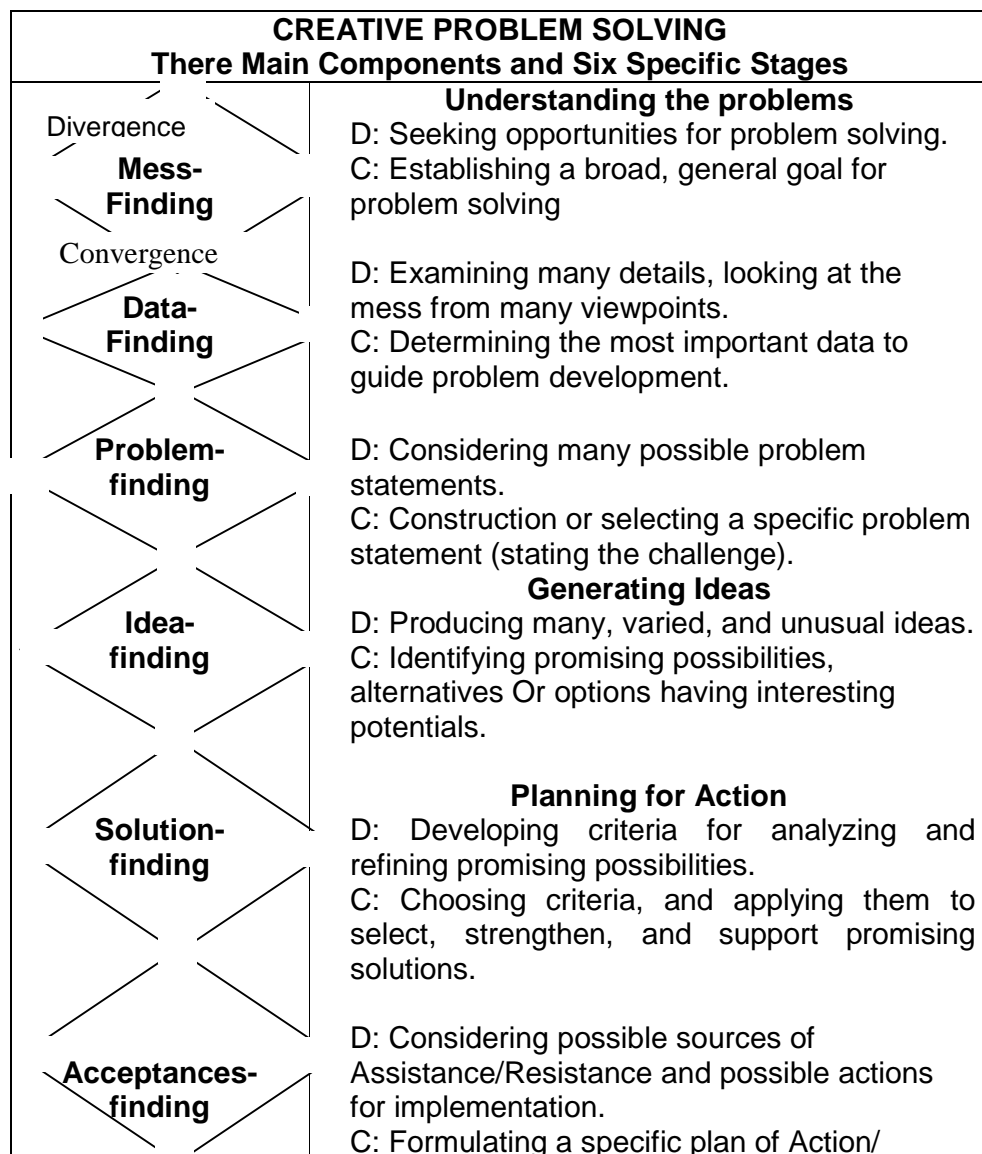


Figure 5.3: Isaksen and Treffinger's 1987 model of CPS including the 3 components and 6 stages

Note 1

Isaksen, Dorval and Treffinger (1994) changed the CPS model again as shown in Figure 5.4.

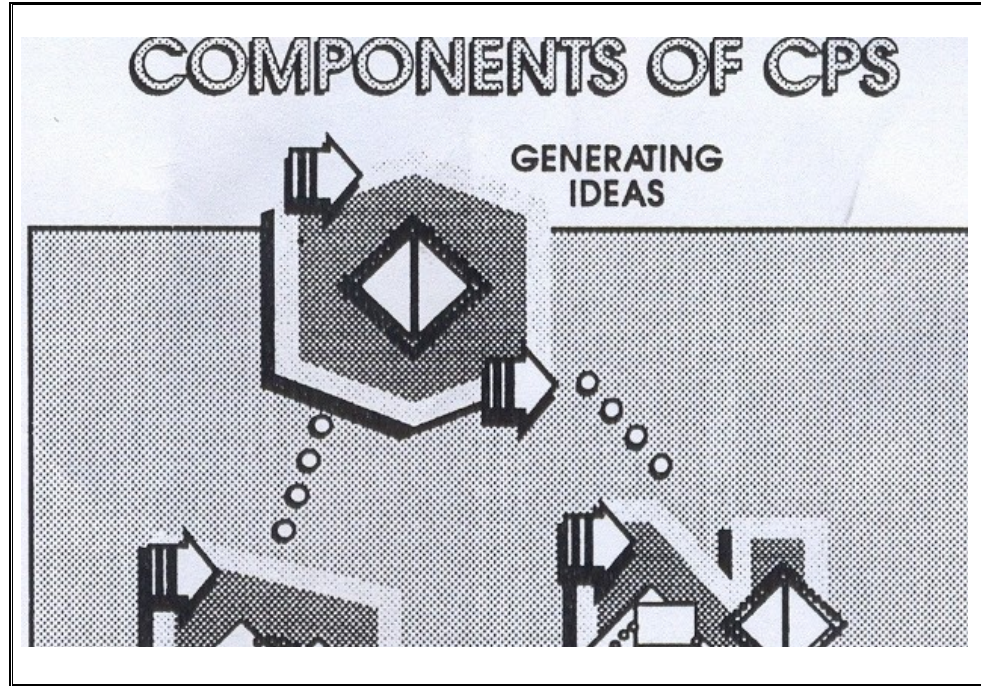


Figure 5.4: Components of creative problem solving (CPS)

Chapter 6: Analytical Thinking as a Style

In this chapter we will represent the characteristics of analytical style as a comparison with critical style and creative style

Characteristics
of Analytical
Style



6.1 Characteristics of Analytical style

There are general styles of behavior common to individuals, and understanding them maximizes your ability to achieve results with others. One such style is that of approaching the world with an analytical slant. Some of the typical characteristics of the Analytical Style include the following:

- Deliberate, controlled, logical
- Independent of others and non-aggressive
- One who weighs all alternatives, remaining steadfast in purpose
- Unemotional, business-like and persistent
- Disciplined, lets others take the social initiative

Analytical
Persons



Analytical persons

- **Approach problems based on facts and logic rather than emotions**
- **See you** performing best in highly organized situations where they have a handle on the whole picture, thus minimizing the risk of being wrong.
- **Tend to do well** when the nature of the task is problem-solving, especially when they are knowledgeable in the area of concern.
- **Probably approach other people** with caution, not revealing your inner self until comfortable.
- **Have a productive competence** in working out a problem and getting the task completed correctly, as one of their key strengths as analytical people.
- **May also have some tendencies with bother their co-workers.** Because they are quiet, unemotional and business-like, some people may feel that
- **Are cold or uncommunicative, remaining aloof from interpersonal relationships.**
- Although you seek accuracy and precision, **their deliberateness may be interpreted at times as slowness** to act or as indeciveness. Sometimes the non-emotiveness of their styles are seen by others as a lack of caring, being concerned only about facts and figures.

- **Tend to take a problem-solving approach to most situations.**
- **Oriented more toward ideas** and data than toward relationships or feelings, they tend to prefer study and contemplation to immediate action.
- **Have a steadying influence** in a group as a restrained and unassuming ways.
- **Typically take an orderly,** systematic approach to the task at hand on the job
- **Like things to be rational and well organized.**
- **Are likely to hesitate** until the task is clear and then work at it persistently and conscientiously.
- **Want to collect many facts** and opinions before making a decision and are good at "buyers' remorse" because they continue to gather data even after a decision is made.
- **Tend not to seek personal recognition, preferring to work in the background in a problem-solving capacity.**
- **Use their ability** as problem-solvers or information holders as the basis for relationships and don't easily take risks or trust others.
- **Are often unaware of their emotions,** though they tend not to initiate relationships, they are loyal after having formed an emotional bond.
- **Usually wait for others to come to them before they share their ideas,** and they want to be sure of their ground before giving their opinions.
- **Hate to be wrong and will avoid it at all cost.** This is especially true in stressful situations, when they are more likely to avoid confrontation and interpersonal conflict.
- **Appear unemotional,** they can be tough and arbitrary when they believe they are "right"
- **Could probably be more effective if they learned to be less serious and to enjoy work more.**
- **Can create an environment** where their methodical efforts are more effective, because they seldom thrive on competition, they are more comfortable with advisory roles Because they may become tense or stuck when confronted with chaos and ambiguity, well-established rules and procedures.
- **Will often cause others to look to them for counsel, precision, and data-oriented expertise** for their steady and quiet manner.
- **May also be seen as boring,** perfectionist, uncommunicative, and incapable of making a decision.
- people with an analytical style **are bothered by these situations in their interactions with others:**
 - **When** they don't know all the answers
 - **When** they have to interrupt others
 - **When** they must deal with overly aggressive or critical people
 - **When** people invade their private space or get too close when speaking

- **When** people do not have all of the facts or will not listen to reason
- **When** someone's behavior is loud and obnoxious
- **When** people are unfocused or don't pay attention
- **When** people pass themselves off as something they are not

On the other hand: Harrison and Bramson describe important qualities of analytical thinkers in this way:

1. Analysts have a **theory about almost everything**.
2. They **analyze and judge things** within a broad framework that will help to explain things and arrive at conclusions.... When a problem is presented, analysts will look for a method, a formula, a procedure, or a system that can solve it...the one best way.
3. They **are most fond of the scientific method**, expert information, and proof". In constant search for the truth that is, the one best way they dig in and may be accused of tunnel vision. For them, still waters run deep
4. People with an analytical style **feel a pull between a natural inclination toward privacy and systematic thought (parts-to-whole) and a deep connection to and feeling for others (whole-to-parts)**.
5. They **feel like an oak and a willow at the same time**, and seem to experience even trivial things with many nuances and meaning. It is not uncommon for someone with an A/P style to have a small but
6. **Deeply engaged community** of friends who share similar interests and simultaneously feel at one with, and responsible for, the world.
7. When **analytical** is the higher score of the two, people with this style **favor theories, concepts, and analysis**, then look to the support and ideas of others for validation and confirmation.
8. The persons with an analytical style **approach life from a gathering-of-multiple-informational-parts-to-whole** perspective that sees the world as a logical system that can be understood through careful analysis and unfailing study. (academic, no-nonsense, logical, theoretical, abstract)

6.2 How to
Improve Your
Interaction
with
Analytical?

6.2 How to Improve Your Interaction with Analytical?

When **communicating with analytical people**, follow these guidelines to improve your interactions:

- Slow the tempo and use more even-tempered presentations
- Provide all the necessary information

- Follow through on your commitments to them
- Provide rational reasoning, not emotional arguments
- Make sure they understand the ``rules``
- Be direct and straightforward
- Listen fully to what they have to say

Characteristics
of Critical
Style



6.3 Characteristics of Critical Style

There are number of Characteristics that distinguish critical thinkers. Such as

1. Critical thinkers **demonstrate critical and analytical thinking** through active challenges and engagement in courses throughout the curriculum.
2. They are **able to analyze arguments and generate insight** into interpretations in ways that display creative, cohesive, and convincing reasoning patterns.
3. They are **able to apply multiple, sometimes divergent criteria** in critical analysis.
4. Persons should develop the thinking and reasoning skills necessary to **evaluate information and to solve problems**.
5. They **recognize and evaluate assumptions and biases** influencing their own positions and those of others.
6. They are **able to identify logical flaws, methodological flaws, and unwarranted inferences** in arguments presented to them.
7. They learn to **apply personal judgments and interpretations**, recognizing that there are elements of uncertainty and self-regulation in critical thinking.

On the other side, a number of researchers describe the critical thinker as follows:

1. **Asks significant and pertinent questions and states problems with specificity.** Arrives at solutions through hypothesis, inquiry, analysis, and interpretation.
2. **Assesses statements, insights, and arguments** according to the knowledge and skills provided by formal and informal logic.
3. **Formulates propositions or judgment** in terms of clearly defined sets of criteria.
4. **Strives to acquire knowledge of the various disciplines**, knowing that such knowledge is a necessary, though not sufficient, and condition for critical thinking.
5. **Understands the different modes of thought appropriate to the various disciplines.** Can apply these modes of thought to other disciplines and life.
6. Is **aware of the context or setting in which judgments are made**, and of the practical consequences and values involved.
7. **Thinks about the world through theories**, assessing these theories and their contexts to determine the validity of their claims.

8. **Seeks and expects to find different meanings** simultaneously present in a work or event.
9. **Recognizes and accepts contradiction and ambiguity**, understanding that they are an integral part of thought and creativity.
10. **Constructs and interprets reality** with a holistic and dialectical perspective. Sees the interconnectedness within a system and between systems.
11. **Tolerates ambiguity**, yet can assume a committed position.
12. **Is aware of the limitations of knowledge** and exhibits epistemological humility.

6.4 Characteristics of Creative Style

Characteristics
of Creative
Style

Kirton Adaption-Innovation theory (KAI)

For more than 30 years, Kirton (1989) worked within organizations trying to understand how change took place. He focused his examination on managers and the change initiatives they created. As a result of his work, he identified two fundamentally different approaches managers took to deal with change. As you read, it might be interesting to think about which style of change you prefer.

Kirton described one group of managers as those whose approach to change was focused on improving existing organizational systems. Their change generally remained within the paradigm of how activities were accomplished. This type of change was often accepted with little trouble or alarm within the organization. Individuals who preferred this type of approach were often in the 'inner circle' of the organization and their suggestions were readily accepted with little confusion "on the nod". Kirton noticed that their changes often made it quickly through systems and that if these managers made a mistake, they were forgiven and told to "think of it as a learning experience." However, these managers often did not see or take advantage of opportunities which emerged outside the existing paradigms or ways of doing business. He described this type of managers as **Adaptative**.

Kirton described a second group of managers who preferred to produce organizational change which was considered radical or breakthrough. This type of "steep change" often existing paradigms and developed entirely new approaches to systems. As a result, these managers were not naturally accepted by the inner group of the organization. If they made mistakes, they were often ostracized. These managers often saw possibilities outside the current approaches. However, they frequently had trouble getting their ideas accepted or implemented. He referred this type of managers as **Innovative**.

Kirton placed the two types of managers on a style continuum. On one side he placed the adaptive style. It will be helpful to start by describing the two endpoints of the continuum where the styles are more clearly distinct.

- **Adaptors** are often seen as people who are precise, reliable and dependable.
- They are generally concerned with how things get done; the means.
- They often make a goal of the means.
- If an adaptor is given a task, he or she will often accept the problem definition as given and will naturally try to solve it within the parameters of the problem definition.
- Their questions will often focus on 'how'. Because of the focus in how things get done, adaptors will by their nature, pay attention to people because they are a part of how things get done.
- Adaptors will generally focus on change which promotes incremental improvement or "doing things better."
- **Innovators** are often seen as unique, visionary and ingenious.
- By their nature, innovators will question how things get done. The means is not a major concern and is often disregarded.
- When given a problem or task, innovators often challenge the problem definition and suggest that the problem really is not the way the problem has been defined. Their questions often focus on asking why. Innovators may be seen as undisciplined and the change they focus on is perceived as radical and is often noticed as breakthrough.
- When these characteristics are operating together, innovators will generally prefer change which is focused on "doing things differently", as shown in Table 6.1.

Table 6.1: Difference between adaptor and innovator

Adaptor	Innovator
<ul style="list-style-type: none"> • Does things better • Seen as disciplined • Accept problem definition • Makes "goals' of "Means" • Precise, reliable, dependable 	<ul style="list-style-type: none"> • Does things differently • Seen as undisciplined • Challenges problem definitions • Questions or disregards "Means" • Unique, visionary, ingenious

Chapter 7: Analytical Techniques

Practice



Analytical thinking, like everything else, **requires practice**. The more you do it, the better you will become at it. You gradually develop the ability to educate yourself.

Van Gundy(1985) presents number of Analytical techniques. Such as:

1. Decomposable matrices technique
2. Dimensional analysis technique
3. Input-Output technique
4. Organized random search technique
5. Relevance systems.

Decomposable
Matrices



7.1 Decomposable Matrices

The method of using decomposable matrices **to analyze problems has been drawn from the work of Herbert Simon**, who has extensively studied human problem-solving processes. Simon believes that complexity in the world has evolved from simple structures organized into progressively formal hierarchic systems. The human body, for example, consists of relatively simple, single cells organized into increasingly more complex patterns of functioning. The concept of a decomposable matrix is derived from Simon's view that hierarchic systems consist of successive, semi-independent subsystems, each of which is less complex than the preceding one (a box within a box within a box etc.)



To understand complexity, complex hierarchic systems can be analyzed using a basic property of their structure: near decomposability. The concept of near decomposability refers of the fact that the subsystems of some hierarchic systems maintain some, although not total, interdependence upon other subsystems. For instance, in a formal organization, there generally will be less interaction between persons of different departments than between persons within the same department. In a totally decomposable system, in contrast, there will be no significant interaction among subsystems.

Simon's thinking in this area also can be extended to analyze complex, ill structured problems. Problems that can be viewed as complex, hierarchic systems can be analyzed be breaking them down into their respective subsystems.

The following steps are used for this process:

- 1- **Determine** if the problem is analyzable subsystems.
- 2- **List the major** subsystems and the components of each.
- 3- **Construct a matrix** of the subsystems and their components.
- 4- **Using a 1 to 5 point scale**, weight the degree of relationship for each of the interactions between and within the subsystems.
- 5- **Select the highest-weighted** interactions for further analysis or generation of ideas.

To apply this technique, **consider a problem of how to improve employee satisfaction within an organization.** Since most organizations generally are viewed as complex social systems with hierarchic structures, this problem can be broken down into different subsystems. Three major subsystems related to this problem are shown in Figure 7.1 and labeled, respectively. Organizational (A), Group (B), and Individual (C). The components of each subsystem next are listed and arranged within a matrix as shown in Figure 7.2 Weights then are assigned to each of the interactions, with higher numbers indicating greater frequencies of interaction or greater importance of the interactions. Based upon this matrix, the problem solver might want to concentrate upon all of the interactions within subsystems (the small triangles created by the diagonal line in Figure 7.1, but pay particular attention to the interactions occurring between the group and individual subsystems, due to the higher weightings given these interactions. Relationships between specific components then could be selected as the focus for generation of problem solutions or additional analysis.

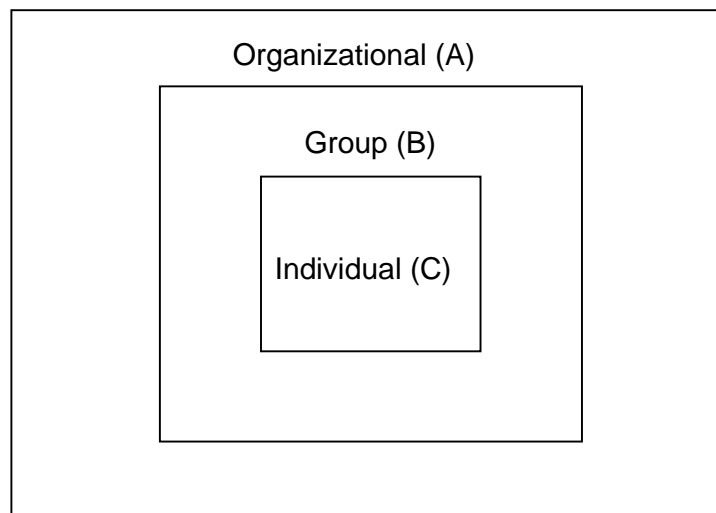
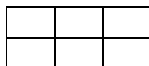


Figure 7.1: Major organizational subsystems.

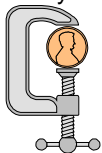
Evaluation This technique is similar to relevance systems in that there is a descending order of problem element. The major difference is in the assignment of values and the consideration given to interactions between as well as within subsystems, both of which are not a part of relevance systems. There are, however, several factors that must be considered when using the decomposable matrices approach. **First**, not all problems can be analyzed into subsystem components or their scope might not justify such a breakdown. **Second**, the effectiveness of this technique will depend upon the problem solvers' ability to correctly identify all relevant subsystems and components and to accurately evaluate the strength or value of all their interactions. **Third**, the ratings are entirely subjective and should be interpreted cautiously. **Finally**, if there are a large number of interactions, problems of coordination might be created. On the other hand, Decomposable matrices should be especially useful for highly system-based problems, such as those encountered in engineering and the social and biological sciences. Because this technique forces identification of problem subsystems, their components, and how they interact, it can cause a clearer picture of important problem elements to emerge, as shown in Table 7.1.

Table 7.1: A decomposable matrix of organizational subsystems and components.

	Organizational			Group			Individual		
	A1	A2	A3	B1	B2	B3	C1	C2	C3
A1 System Design		5	3	2	4	1	1	1	1
A2 Organizational Goals			4	3	2	1	1	1	1
A3 Power				3	2	3	1	1	1
B1 Leadership					4	5	3	2	4
B2 Communication						4	3	2	4
B3 Cohesiveness							4	1	4
C1 Needs								5	5
C2 Values									5
C3 Expectations									



Dimensional Analysis



7.2 Dimensional Analysis

An analytical method designed to clarify and explore the dimensions and limits of a problem has been developed by Jensen. The technique, which will be referred to as Dimensional Analysis, examines five elements of a problem.

1. Substantive dimension.
2. Spatial dimension.
3. Temporal dimension.
4. Quantitative dimension.
5. Qualitative dimension.

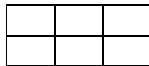
Each of these dimensions is directed answering, respectively, **five fundamental questions: What? Where? When? How much? How serious?** As shown in Table 7.2, the dimensions then are further analyzed by responding to a series of specific questions.

Although not described by **Jensen** as a **step-by-step** procedure. Dimensional analysis could be used as follows:

1. **State** the problem.
2. **Briefly** write down separate descriptions of the problem in terms of what? Where? When? How much? How serious?
3. Using these descriptions, **answer** the questions listed for each of the dimensions, as shown in Table 7.2.
4. **Evaluate** the answers to these questions by considering the implications of each for solving the problem.
5. **Select** those areas most applicable to the problem for further analysis.

Table 7.2: Example of dimensional analysis component

Substantive	Spatial	Temporal	Quantitative	Qualitative
1. Commission or Omission?	1. Local or Distant	1. Long-standing or Recent?	1. Singular or Multiple?	1. Philosophical or Surface
2. Attitude or Deed?	2. Particular Location(s) Within a Location	2. Present or Impending?	2. Many or Few People?	2. Survival or Enrichment?
3. Ends or Means?	3. Isolated or Widespread?	3. Constant or Ebb-and-Flow?	3. General or Specific?	3. Primary or Secondary?
4. Active or Passive			4. Simple or Complex?	4. What Values are Being Violated?
5. Visible or Invisible			5. Affluence or Scarcity?	5. To What Degree are the Values Being Violated?
				6. Proper or Improper Values



Evaluation One difficulty in using dimensional analysis stems from Jensen's definition of a problem as a violation of values. While it might be true that some problems involve value violations, the definition might have to be stretched a bit to accommodate all problem situations. Thus, a problem of how to redesign a toaster to be more efficient would seem to be quite different from a problem of how to reduce racial prejudice. Although the inefficiency of toaster involves a value, a broader definition of a problem would seem to be more useful.

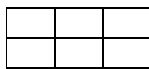
On the other hand. Jensen's emphasis upon human-relations problems represents an area often neglected in many problem-solving techniques. Because of this focus upon social and psychological problems, some selectivity will need to be exercised in using dimensional analysis to analyze technical problems. In the area of new-product development, for example, the question of attitude or deed would need to be modified.

Another difficulty is that little guidance is provided on how to use the technique to analyze a problem. It should be noted, however, that Jensen does not refer to Dimensional Analysis as a technique. Rather, he has attempted to describe five areas to explore when analyzing a problem. Nevertheless, the description would have been more helpful if a systematic analysis procedure had been included. In particular, it would have been helpful to know why Jensen considers the different questions to be important, and how he would suggest that they be used. The step-by-step procedure described at the beginning of this section should be of some assistance in using Jensen's approach.

Aside from the lack of a systematic procedure, the technique should be useful in forcing a problem solver to consider the many implications associated with various problem are selected, problem-solving activity might proceed more smoothly than if no analysis was performed. **The trick**, of course is knowing which dimensions and questions are relevant. Of the questions described by Jensen, Table 7.3 would seem to have the broadest applicability.

Table 7.3: Dimensional analysis component

Substantive dimension :	Ends or means? Active or passive?
Spatial dimension :	Local or distant "Particular location(s) within a location? Isolated or widespread?
Temporal dimension :	Present or Impending? Constant or Ebb-and-flow?
Quantitative dimension :	Singular or multiple? General or specific? Simple or complex?
Qualitative dimension :	Philosophical or surface? Primary or secondary? What values are being violated? To what degree are the values being violated?



In addition to problem analysis, dimensional analysis also might be useful for evaluation alternative solutions or for pre-problem-solving. After a problem has been analyzed and redefined (if necessary), and alternatives generated, the implication derived from the questions could help to bring forth possible problem areas associated with different alternatives. Perhaps the best use of the technique, however, would be

as a checklist for use during pre-problem-solving activity, or as a general guideline preceding the use of some other analytical method. Such a checklist could help to provide a general perspective during the later stages of the problem-solving process.

Input-Output

7.3 Input-Output

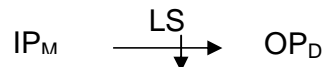


The Input-Output technique **was developed at the General Electric Company to aid in solving dynamic system-design problems involving various forms of energy**. That is, it was intended to assist in the design of physical devices that are functionally dependent upon different energy forms. As a problem analysis technique, however, it should prove useful for specifying connections between the elements of a variety of complex, dynamic problems. Thus, it should be suitable for problems in such areas as social planning, human relations, biology, and engineering.

The basic procedure for using the input-output method involves the following steps:

- 1- **Establish** the desired output (OP_D).
- 2- **Establish the major input** (IP_M) affecting the output.
- 3- **Establish any limiting specification** (LS) that the output must meet.
- 4- **Examine** the connections between the inputs and outputs and determine how the inputs can be best used to achieve the desired output.

At its simplest level, this process can be represented as



Unfortunately, **most problems do not lend themselves to such a simple analysis**. Because many problems involve combinations of inputs and outputs, a slightly more complex version of the procedure is often required. An example of a more complex model is shown in Fig. 13. In this case, the **major input (IP_M)** can produce multiple **outputs (OP_1)** that function as **first-order inputs (IP_1)** producing **outputs (OP_2)** that function as **second-order inputs (IP_2)**, one of which might produce the **desired output (OP_D)**. It should be apparent that more complex models could be developed with multiple input-output steps, each of which could branch out into progressively larger numbers of inputs and outputs.

It also should be apparent that the steps used in implementing the basic input-output model will not be adequate for dealing with more complex problems, as shown in Figure 7.2.

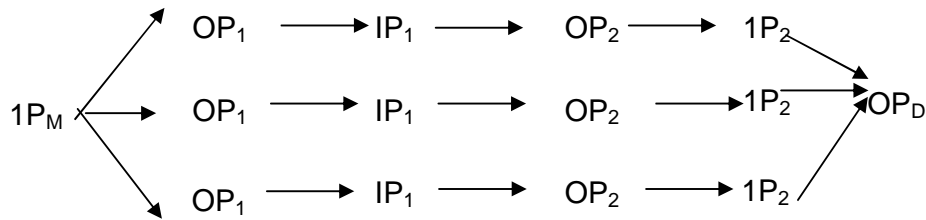


Figure 7.2: Complex input-output analysis

Steps will need to be added to sort out the different input-output transformations and to determine which branches will most likely lead to the desired output. A general procedure for more complex analyses might be described as follows:

- 1- **Establish the desired output** (OP_D).
- 2- **Establish the major input** ($1P_M$) affecting the output.
- 3- **Establish any limiting specifications** that the output must meet.
- 4- **Determine which outputs** (OP_1) are produced directly by the major input.
- 5- **Considering the first-order outputs** (OP_1), as inputs ($1P_1$), determine which outputs (OP_2) might be produced by each input ($1P_1$).
- 6- **Considering the second-order outputs** (OP_2) as inputs ($1P_2$), continue transforming inputs and outputs until the desired output (OP_D) is achieved.

An example described by Whiting might help to clarify this procedure. Whiting describes a problem of how to develop a mechanical device capable of providing a warning in the event of fire. In this case, the **desired output** (OP_D) is the warning device, fire is the **major input** ($1P_M$), and the special requirements of the device are such factors as size, cost, and sensitivity level. **The outputs** (OP_1) associated with fire are: heat, light, various gases arising from combustion, and smoke (the first-order inputs). By redefining these outputs as **inputs** ($1P_1$, in Fig. 3-4), we can create new **outputs** (OP_2) - such as the expansion of metal subjected to heat, or chemical reactions caused by light and smoke. The task then is to select the **outputs** (OP_2)- transformed into **inputs** ($1P_2$)- that seem to be most capable of functioning as a **fire-warning device** (OP_D). **For example**, a smoke-sensitive chemical or a metal that melts below the boiling point of water could be used to trip a circuit that would an alarm.

Evaluation



Evaluation This technique is similar to the redefinition procedures since the transformations between inputs and outputs represent progressive redefinition of the inputs. It was classified as an analytical procedure because of the required breakdown of problem sub processes.

Analyzing a problem through the use of various input-output relationships can be a valuable exercise, especially for problems that involve some type of energy transformation. Furthermore, when multiple input-output steps are used, such a breakdown of problem aspects can help coordinate and clarify the idea generation process. **A major weakness of this method**, however, *is that analysis of problems involving large number or inputs and outputs can be a time-consuming and often confusing task.* For this reason, the input-output method will be most suitable for only moderately complex problems that are considered to be important enough to justify using the procedures involved. Of course, computer programs exist that can overcome this weakness.

Organized
Random
Search



7.4 Organized Random Search

One method for systematically analyzing a problem is the Organized Random Search developed by **Frank Williams**. Instead of randomly searching for ideas, Williams proposes that it is better to **first break down the problem into its different subdivisions or parts**. These then can be used to provide a direction for the generation of ideas. The steps are as follows:

- 1-Inspect the problem for possible subdivisions or ways of categorizing parts of the problem.
- 2-Write down the different subdivisions or parts and use them to generate ideas.

Williams provides an example of a problem involving recall of the names of all the U.S. states. If total random recall was used, it might be difficult to recall all the names except for the more popular ones or ones with some personal meaning attached to them. If, however, the search process was organized using geographical areas, the number of states recalled should substantially increase. Thus, the states could be clustered to include east and west coasts, central states, and so forth, and the names then recalled from within each area rather than from the entire United States. With such an analysis, the search for ideas still will be somewhat random, but at least it will be organized.

Example

Another example, actually used by engineers in one company, was a **problem of how to keep current in the problems and solutions within their areas of responsibility**. Before attempting to generate ideas to solve this problem, the engineers broke it down into two areas: people and things. These areas were then further subdivided into internal and external aspects. The internal-people area contained items such as superiors, subordinates and staff while the external area listed customers, suppliers and competitors. Each of these breakdowns was then used as the starting point for generating ideas.

Evaluation



Evaluation This method is similar in concept to **Decomposable Matrices, Morphological Analysis, and Relevance Systems**, all of which involve factoring a problem into its major elements to stimulate and clarify the idea generation process. These technique, however, are somewhat more structured and systematic than the organized random search method. In particular, decomposable matrices and relevance systems contain a degree of sophistication not present in the basic analytical procedures of morphological analysis and organized random search. The use of binary systems, opportunity interfaces, and matrix weightings are elaboration that significantly increase the usefulness of these methods especially for complex problems. Nevertheless, for problems containing few dimensions and having minimal interaction among the dimensions, the organized Random Search method could be an appropriate choice.

Relevance Systems



7.5 Relevance Systems

Relevance systems **represent a method of organizing information about a problem through successive refinements of major problem elements**. As each element is listed, other elements are identified and connected with the preceding ones until a pyramid-like structure results. A common example of relevance systems in the formal organization chart. Top-level managers are listed at the top and then connected by lines to progressively greater numbers of persons at lower organizations levels. This particular type of relevance system is comparatively easy to construct since the problem is essentially well-structured. It is more difficult however, to construct a relevance system for ill-structured problems due to the often unknown qualities of problem elements and constraints.

According to **Rickards**, *there are two types of relevance, systems: single and binary*. A single system consists of all the elements related to a single problem; a binary system is comprised of two single systems that interact across the lower levels of the two systems (the opportunity interface). Thus, binary systems can be used to identify relationships between as well as within systems.

Relevance systems can be constructed in **two different ways**. (1) **starting with the highest-order** elements and sequentially connecting elements in a downward direction, and (2) **starting with clusters of lower-level** elements and working upwards to the highest level . Although either method will produce a workable relevance system, better results generally will be produced if both methods are used. **By working downward and upward, the validity of the elements included and their relationship to one another can be more easily assessed**. The following basic steps are involved in constructing Relevance systems:

- 1- **Write down** the highest-order element of the problem (the first-level element).
- 2- **List the sub elements** that can be derived from the first level (the second-level elements).
- 3- **Continue listing lower-level elements** until all possible levels have been exhausted and the lowest level has been achieved. Achievement of the lowest level usually can be determined by looking for elements that answer the question: How? Higher level elements, in contrast, usually answer the question: Why?
- 4- After completing this systems, **asses the system's validity** by working upward for the lower-level elements.
- 5- **Use the lower level elements** to suggest possible problem solutions.
- 6- **If the problem overlaps** another area and need to be integrated with it, extend the system by construction a second system so that its lower-level elements interface with those of the first system. The result will be a binary relevance system.
- 7- **Examine the interface** to determine points of singular or mutual influence and/or to consider possible constraining factors that might affect the objectives expressed within either system

Example

An example of how a binary system could be used to improve a company's marketing strategy has been described by Rickards. As shown in Figure 7.3, a single system is constructed with the highest-order element being increasing the number of clients. Two lower-level elements are developed next (still asking the question: Why?), followed by the lowest level of elements, which are oriented toward the question How? Then, if it is determined that the marketing strategy should be integrated with the overall policy decisions of the company, a second system could be constructed also shown in Figure 7.3. The resulting binary system allows both policy makers and marketing personnel to analyze any possible constraints that might influence potential problem solutions. For example, changing the company image could conflict with a policy alternative of increasing university contracts.



Evaluation Because of its emphasis upon identifying connections among problem elements, the **Relevance systems method is very similar to Progressive Abstractions.** *Both techniques rely upon progressive breakdowns of problem elements and development of new problem definition.* The techniques differ slightly, however, in their use of problem elements. For Progressive Abstractions, increasingly abstract problem definitions are developed by synthesizing preceding problem solution, for Relevance Systems, a problem is broken down so that all of its major elements and their connections can be examined. **For some problems**, the distinctions between the two techniques might be difficult to make. In such cases, the choice of technique might be made more on the basis of personal preference than any advantage of one technique over the other.

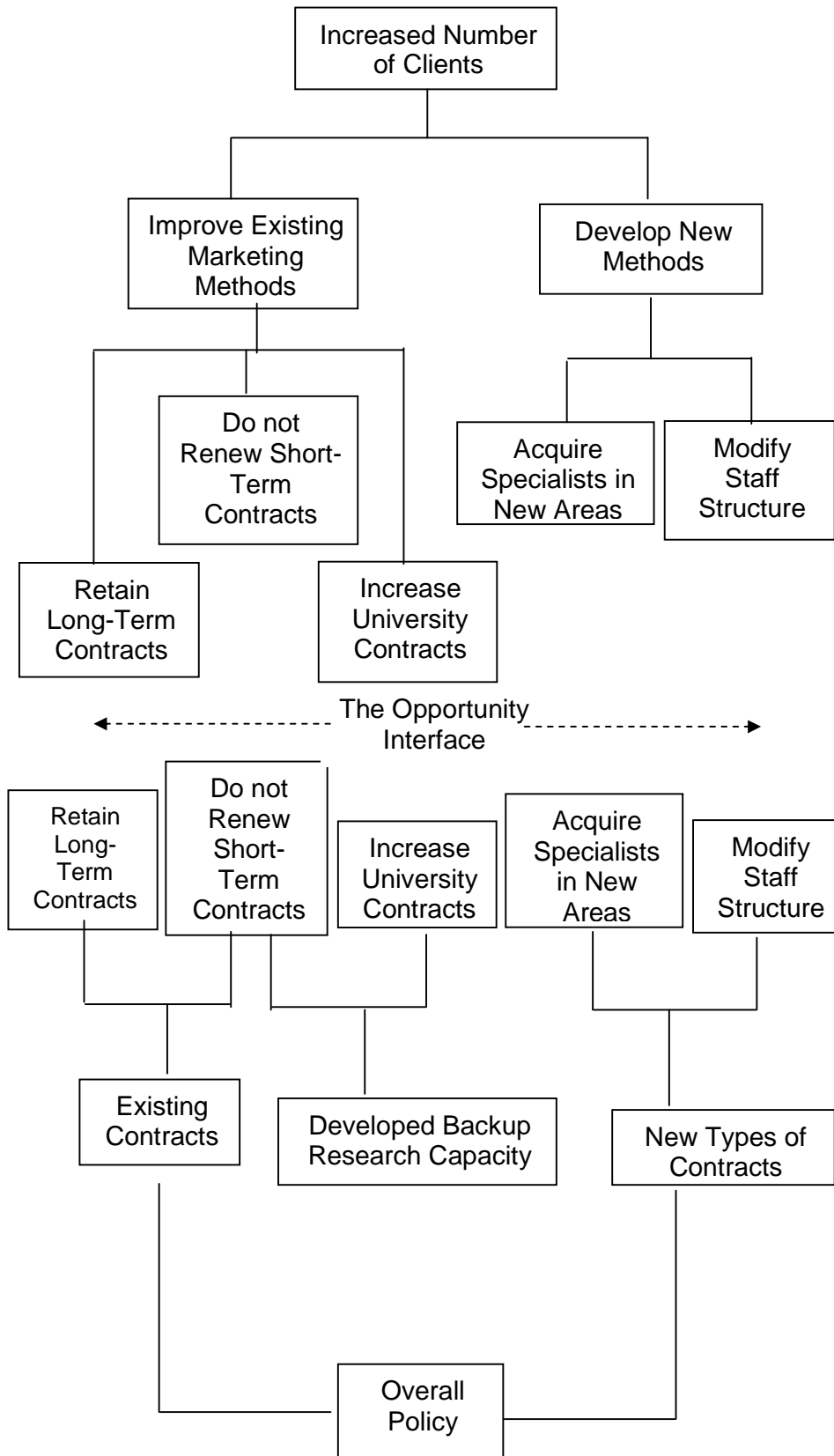


Figure 7.3: Binary system

Relevance Systems, however, are distinguished by taking into account the possible need to integrate one system with another. In addition to suggesting problem solutions that might not be considered with the Progressive Abstractions method, opportunity interfaces are an important strength of Relevance Systems. Because a problem solver is forced to consider potential - solution constraints, the likelihood of solution revisions should be reduced considerably. Another advantage of Relevance Systems over Progressive Abstractions is suggested by Rickards, who indicates that the possible overlap of lower-level elements will increase the richness of problem solutions. When different combinations of problem elements are forced together, more unique solutions should be produced.

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