The Age of Synthesis

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As we enter the 21st Century we are in the beginning stages of a new age of synthesis, philosophically and technologically. The major forcing function is the consumer demand for manufactured products, processed foods, and mass works of art. It is expected that these demands will be met without negatively impacting the environment, using a minimum of energy, and under safe conditions. This new age of synthesis is being built on and utilizes the emphasis on analysis featured in the 20th Century. There is not a sharp distinction identifying the beginning of the age of synthesis, with activities gradually developing, as illustrated by chemurgy in the 1930s. Synthesis as used in the philosophical sense has been with us for centuries, but has been mostly dormant until recently, while analysis held the spotlight. Synthesis is an important activity in science, engineering, the other professions, and the applied fields, but has not been generally accepted. Synthesis is now becoming alive and will take its place beside analysis as an important approach, particularly for unnatural and constructed systems. Educational systems need to incorporate instruction and practice in synthesis to better prepare human resources for the future. Group efforts and multidisciplinary efforts predominate in synthesis activities.

The methods of thinking, reasoning, and dialectical argument focus on the two categories of analysis and synthesis. Synthesis is used in the broadest sense as a way of thinking, as well as for the substitution or replacement or imitation of materials and systems and for the development of new systems. The development of new materials and systems is emphasized — that is the artificial or artifacts or unnatural in contrast to the natural.

The Setting

Synthesis is the process of making or producing what is otherwise natural and also of making things that nature could not or did not make under natural conditions.

Synthesis is becoming ever more useful and applicable not only as an approach for larger artificial systems with more components involving more complexity, but also in considering human systems, either alone or as a part of unnatural or artificial systems. Examples of such systems with human elements as well as technological components include food production and processing, medicine and health, and financial and educational systems.

Analysis has been dominant during the present 20th Century and was built on the developments, often philosophical in nature, of its predecessors in previous centuries — ideology, enlightenment, and reason. For the next century synthesis will continue to grow in importance as a result of the increasing involvement in conceiving, building, and assembling artifacts and systems. This process of synthesis will itself be the subject of considerable analysis.

Synthesis of a substitute or imitation of a thing that is already existing, such as synthetic rubber, is different from synthesizing something previously unknown, particularly a large system such as a worldwide communications system (especially the original one). The first approach involves considerable analysis of the original material or system that may be used to inspire or guide the work; the second requires a creative approach into the less well known. Synthesis can provide a way of projecting thoughts to meet future needs and to satisfy wants. Synthesis provides a framework for guiding analysis, research, development, management, and education.

There will be much interchange of terminology between philosophical or natural and artificial or unnatural systems. Terminology used in analysis and synthesis was first developed with respect to philosophical considerations, then was applied to natural systems, and now is being applied to artificial systems. Philosophers of old wrote of atoms without knowing what they were, and the term was then used extensively. Lavoisier (1743-94) referred to ". . . elements as the last point reached by analysis . . ." in referencing chemicals and the state of knowledge in his day. Terminology that was developed for physical systems is now being applied to philosophical systems, particularly as related to energy and the environment.

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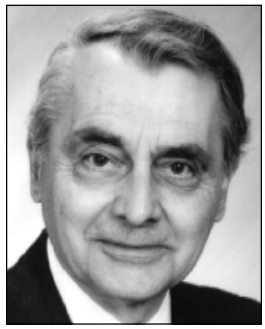

Dr. Hall has held consulting and professional assignments to industry, foundations, universities, the National Research Council, and the United Nations, has served as president of the ASAE and as director of the ASAE and the NSPE, and has been active at the national level in ABET and the ASEE. A member of the National Academy of Engineering, he is a fellow of the AAAS, ASAE, ABET, and the ASME, is an author or editor of 29 books, and has won numerous national and international awards.

Synthesis is a way of thinking and doing, of providing a vision, in which an idea or a thing, imagined or real, is seen as a coherent whole; often consisting of parts, from which thought can be developed, action can be rejected or taken, and the thing made, assembled, or constructed; either as a new creation or activity or as a duplicate or substitute of known substances.

Brief Background

The *Age of Synthesis* is based on the premise that philosophical thought has developed and evolved from the earliest days of learning, undoubtedly preceding written history and usually rooted in the search for truth. For example, early weapons began with the materials literally at hand, and the desire to improve the capabilities of weapons became a driving force for new methods and materials. Developers responded to "what if. . . ?" — an approach still used, elevating synthesis as an effective approach. As we reflect today and perhaps conclude that the early thinking was primitive, those beginnings were important — each step in the development providing a new foundation for the next step.

Philosophical thought was developed on concepts that became the basis of scientific approaches, categorized as natural philosophy. During the early years the term *philosophy* was generally abandoned in relating to real-world objects and applications. Those who embraced things or artifacts of the world were not considered philosophers. Early developments in philosophy consisted of developing the thought process and expressing the thought process through the language. Early religious and legal thought was built on synthesis of knowledge. Later and recent developments consisted of applications to things; thus, there has been an evolution over the centuries from thoughts to words to things.

Analysis and *synthesis* were among the terms used to describe the thought processes. Except for a few people such as Archimedes, Michelangelo, Leonardo da Vinci, and Shakespeare, whose exploits of creative thinking and synthesis approaches are well-known, analysis was dominant and was the basis for most of the thinkers. *Analysis* and *synthesis* have been recognized as methods of exercising the thought process to provide things resulting from thinking. As systems have become more complex, particularly unnatural systems, there has been an increase in the amount of synthesis involved.

Chemists have used synthesis as a means of duplicating, substituting, and imitating as a major effort; biology has combined evolution and synthesis. Architecture and engineering, those professions with a design thrust as a basis of a built- or constructed-device or system in contrast to a natural system, use synthesis to a much greater extent than scientists.

Future developments of things and systems of things will incorporate to an increasing extent the synthesis approach — integrative, interdisciplinary, interconnected, imaginative, . . . holistic — and to larger and larger systems, not necessarily larger in size, but in numbers of components and interactions.

Human systems (business, economics, education, government) will increasingly follow these patterns in the 21st Century, often combining human activities, behavioral systems, and artificial systems in a mix of natural and unnatural systems. The wide use of computers has greatly increased the interactions among human, natural, and unnatural systems.

Concepts

The *thoughts-to-things* process assumes that one initiates thorough thinking, then puts thoughts into a form that can be passed to others by speaking and writing, and then applies those thoughts to an imagined, natural, unnatural or artificial (built) thing or system. End use is a driving force in synthesis, whether innately as in a natural system or teleologically (design) as in an artificial system.

Analysis and synthesis are involved in each step from thoughts to things. It is probably impossible to identify an activity that is either pure analysis or pure synthesis. Analysis predominates in the study and knowledge of natural things and systems. Synthesis predominates in development of unnatural or artificial (human made) things and systems. Words that describe the synthesis of the artificial include: *systemization, interfaced, interconnected, integrated, interrelated, interdisciplinary,* and *multidisciplinary*.

During the 20th Century, analysis has predominated in philosophy and science as people have learned much about themselves and nature. During the 21st Century, synthesis will dominate as the information about nature and the imaginations of people are combined to produce an abundance of artifacts, which are artificial or unnatural systems. The products of synthesis will be the subjects of considerable analysis, not only in a materials sense, but also in human systems. Likewise, there is an increasing recognition that there is a significant contribution to the creative process resulting from the reverse flow from things to thoughts — that is, each new product (artifact) stimulates the creative process. As a result of the proliferation of artifacts and artificial systems, the general public will become more involved in controlling, restricting, and limiting these systems.

Thoughts-to-Things

THOUGHTS: There is a synthesis of thoughts as a result of thinking within one's intellectual system. Thoughts are based on knowledge, experience, and imagination, producing data, information, images, and ideas. Locke says that there are three degrees of knowledge: intuitive, demonstrative, and sensitive (that which can be sensed). Analysis is involved in this domain to sort out the information for the thesis or other transfer function from thoughts to things. Adler originally published 'The 102 Ideas of the Western World" in 1952, an irreducible

list that still stands. These ideas were a part of the Greek culture 2000 years before. Neither *analysis* nor *synthesis* appears on the list, but *universal and particular* does appear as an entry, illustrating the complementary nature of analysis-synthesis.

THESES: there is a synthesis of ideas and thoughts from numerous people, from the written, spoken, and visual representations providing a design, publication, treatise, or speech. Analysis is involved in this domain to sort out and develop the pertinent information to help meet the end use of things. As thoughts are dispensed, activities often move from individual to group or team efforts.

THINGS: there is a synthesis of different things (artifacts) for replacement of items or systems, for a larger sphere of items or things, and for new items or systems. An action is required to accomplish THINGS. Analysis is involved to provide the most appropriate artifact for the end use, such as in the economy, energy, material, and environment. Aristotle speaks of *productions* that could be considered as things. As one moves from THOUGHTS-to-THESES-to-THINGS, there is an increasing use of synthesis. In the reverse order, there is an increasing use of analysis that can be used to improve the results of synthesis.

The world is made of many things, big things, even the Earth itself. The importance of growth and synthesis may be more fully appreciated if one contemplates an answer to the following statement: Name a thing, anything, that started big.

Thinking is the ability to draw inferences, solve problems, and answer questions on the basis of information from perception and memory. Perception has a strong pull on the process. In many human processes, such as in politics and advertising, much effort is exerted to assure that perceptions of a person or product are favorable (or that perceptions of a competing idea, person, or product are unfavorable).

Synthesis is a way of THINKING, an attitude, an approach, a way of doing, followed by action to meet the end-use objective, with an accomplishment or non-accomplishment, if unfeasible, to produce THINGS. The synthesis approach adds something new to the subject and process.

Synthesis Inspired by Thoughts

Some people have the ability to inspire others to think, even though the listener does not comprehend the subject, by their challenging speech or writing, their proposal of ideas, and their facility of expression.

R. Buckminster Fuller (1895-1983) could talk for three hours at a "one-hour" lecture and express hundreds of ideas, stimulating listeners of various backgrounds who often did not understand much that was said. Isaac Asimov (1920-92) was an imaginative and prolific writer who excelled in both fiction and non-fiction. He wrote on numerous subjects and was a master at making the difficult more easy to understand, often by presenting the pieces as a part of the whole.

Although there are many benefits and new insights to be gained by using synthesis, there is a danger of being misled by myths and miracles. Thoughts evolving from myths, imagination, and perceived miracles become inspirations for new approaches, but they need to be challenged and tested. Control is needed to prevent synthesis from being used as a vehicle for promoting the occult or witchcraft.

It is difficult to capture the depth of understanding of Socrates, Plato, Aristotle, Kant, Emerson, and the others whom we anoint for their insights on analysis and synthesis. They never dreamed that we would be applying their ideas to our THOUGHTS to THINGS of today, particularly to artificial things or artifacts.

Summary

Ideas are the result of thinking. These ideas are the precursors of more definitive knowledge about natural things and systems. These ideas become the framework of knowledge needed to build artificial things and systems, thus effecting a flow of thoughts-to-things, with a transfer function between them. The first action is more likely to emphasize analysis — the second, synthesis. An interplay between analysis and synthesis is involved, each helping the other along to some higher knowledge and understanding of natural and unnatural things and systems. Synthesis is a way of thinking as well as a procedure for making a thing. Synthesis involves thinking with a goal, an end, or an objective in mind, involving integration of elements, components, and subsystems to form a system.

Synthesis has obviously had an important role in developing new artificial products, substitutions, and imitations. Artificial systems have become larger and more complex and now include more components than previous systems. Synthesis thinking is becoming recognized as an important approach for developing and improving human systems, many of which involve both natural systems and artificial systems. Education and research should involve a greater emphasis on synthesis, as government and the population in general become increasingly involved in controlling and setting the rules for natural and artificial systems.

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