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Context for Creativity

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Abstract

A simplistic and seriously misleading myth about creative thinking is that creative processes are exclusive alternatives to systematic processes. In fact, breakthrough thinking almost always is preceded by extensive preparation, and the order in which issues are considered has much to do with how they are resolved. A better way to think about creativity and design is to think about how to place the different styles of lateral and vertical thinking together in a process that takes best advantage of both at appropriate times.

A design process, Structured Planning, is examined in this article for how it embeds concepts of preparation and manipulation from the classic creativity model in its systematic scheme. Its Action Analysis phase exhaustively catalogs the functions necessary for a successful design while, at the time of identification, uncovering insights and capturing ideas for creative ways to perform the functions. Its Structuring phase organizes the functions for systematic consideration, but does so in a way that supports invention by clustering functions in groups that are frequently counter-intuitive, but ought to be considered as groups because they have potential solutions of common interest. The result, an information structure specialized for inventive design, defies the natural tendency to a priori categorization.

Introduction

Most people are creative—at least they probably *were.* Our schools, institutions and businesses tend to wither natural creativity, but fortunately for many, a little nurturing can bring back the knack.

That's the good news. The bad news is that random creativity, particularly in business, won't be enough in the new economic world.

The trouble is, you just can't invent or discover at whim. The myth that creative people deliver brilliant ideas on demand discourages otherwise perfectly able people from trying. The fact is that ideas seldom come without extensive preparation. Edison and many others before and since have said it in one form or another, *"Genius is one percent inspiration and ninety-nine percent perspiration"* [Evans 1968, 266]. Yet, the creative element obviously is very important. How can inspiration and perspiration be deployed optimally?

Psychologists have probed the perplexities of creativity since the discipline was formalized. Most agree on a similar set of states or stages that an individual passes through in developing an idea. Typically, these are [Fabun 1968, 9-12]:

1. Desire
2. Preparation
3. Manipulation
4. Incubation
5. Intimation
6. Illumination
7. Verification

There is necessarily also a "0" stage that is concerned with life preparation—it is easier for those with broad interests to make creative associations. Nearly all agree that wide-ranging experience is beneficial to the creative individual, simply because it provides a base of analogies and metaphors upon which to draw. From a methodological viewpoint, unfortunately, there is little to be done in the way of life preparation. Except that the use of teams extends the range of experience available, life preparation is generally outside the purview of a design project.

Stage 2 preparation, however—that part related to the project—is of great importance to the creative process. Here and in the manipulation stage, Edison's observation can be put to work to set in motion reliable, predictable invention, as close to on-demand creativity as I know how to achieve.

After years of experimentation, our experience at the Institute of Design suggests that the way that information is assembled and organized in a project is absolutely critical to the creative quality of the result. To bend a phrase, *creativity ignores a vacuum.*

First, insights must be sought throughout the search for information, and ideas must be teased from them as they occur. Second, information must be organized properly, so that ideas can be merged, modified and expanded in direct association with the right problems to be addressed.

A process developed at the Institute of Design, called Structured Planning [Owen 1988], includes techniques for a complete process of problem description, information collection, organization and ideation. In this paper, I will discuss ideation as it is incorporated in Structured Planning, viewing the process through the psychologist's model of the stages of preparation and manipulation in the creative process.

Preparation

"As the first step toward satisfying the desire, both pertinent and seemingly impertinent information are gathered. This may be through research, experimentation or exposure to experience. ... The process is analytical, and is a way of 'making the strange familiar'" [Fabun 1968, 10].

Action Analysis

In the Structured Planning process, the collection of detailed information for a project is done with a technique called Action Analysis. Action Analysis achieves its value from the thoroughness with which it seeks out the **Functions** that must be performed by the system being designed (I will call the object of design a "system", even though it may be any kind of entity—hardware or software, artifact or institution). The objectives of Action Analysis are to identify as many as possible of the Functions that the system should perform (or have performed to it) and to gain as many insights as possible about what goes wrong or right as these Functions are performed.

To achieve the objectives, the design team undertakes a top-down analysis, establishing for the system a *Function Structure* breaking down all actions into three hierarchical levels of operation. Figure 1 shows a simplified, partially filled-in Function Structure for a housing system project in which the challenge was to design a "house of the future" embodying state-of-the-art communication and control technology.

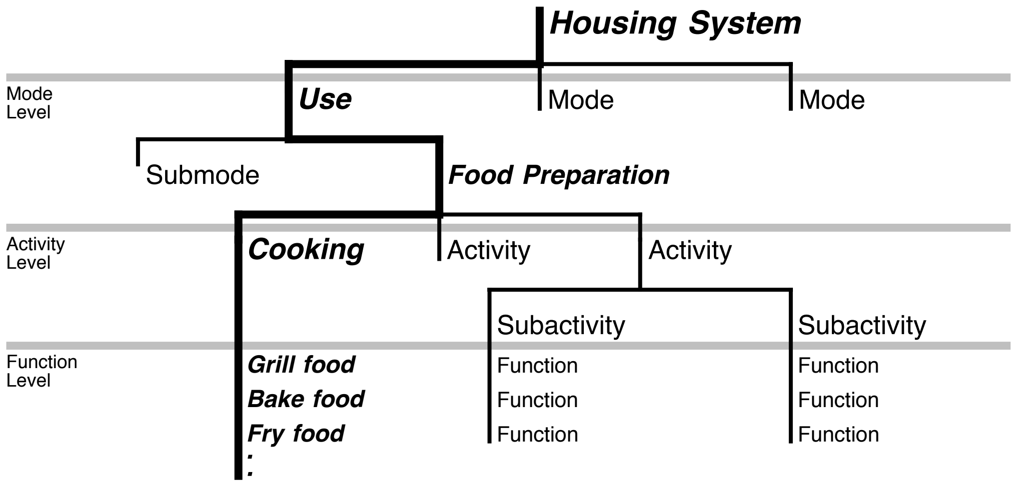

Figure 1. A three-level, top-down analysis is used to find **Functions** *that cover the requirements of a system. The result is a* **Function Structure.**

Modes of operation, or ***Modes,*** are at the highest level. These are usually very distinct states that the system goes through from the time it is produced until it is retired. There are relatively few possibilities, although the selection varies for every system. Some of the more typical Modes considered are:

- *Production*
- *Distribution*
- *Specification*
- *Transport*
- *Sale*
- *Use*
- *Storage*
- *Maintenance*
- *Repair*
- *Adaptation*
- *Retirement*

There may also be ***Submodes,*** if necessary, for some Modes. The Use Mode is a frequent candidate for Submode treatment because a system often has a range of uses under different conditions.

The middle level of the hierarchy is the ***Activity*** level. For any Mode of operation, it is usually possible to describe several Activities that occur in accomplishing the purpose of the Mode (for example, *Loading, Transiting* and *Unloading* for the *Transport Mode*). Activities are defined as "purposeful performances" in Action Analysis. The use of the theater metaphor is very intentional. Thought of as scenes of a play, Activities can be characterized nicely and distinctively and, therefore, may be described relatively precisely.

For a theatrical scene, there are players, props and a set. In an Activity, there are users (players), system components that the users work with (props), and environmental components that are not involved directly, but place conditions on the system (the set).

Once an Activity is described, it is relatively easy to go to the next level to identify the *actions* that are performed during the Activity, both by the system and by users operating the system. In keeping with design nomenclature, the actions are described as Functions— **System Functions** or **User Functions,** depending on whether they are performed by the system or by the user. This Function level is the third and lowest level of the Action Analysis hierarchy. At this level we attain the level of detail necessary to meet the goal of the analysis, uncovering the Functions that must be performed. Thorough coverage means thorough design. Careful preparation of a Function Structure produces the foundation we need for a creative, holistic approach to concept development.

Action Analysis	Activity/Event: Cooking	10
Originator	Project	Mode
C. Owen	Housing System	Use (Submode: Food Preparation)

Users	System Components	Environmental Components
Cook	Stove	Work surfaces
Cooking helpers	Oven	Task lighting
	Microwave oven	Sinks
	Pots and pans	Storage units
	Recipes	Garbage disposal
	Food ingredients	Used and unused vessels
	Refrigerator	
	Freezer	
	Utensils	
	Work surfaces	

System Functions	Associated Design Factors
25. Grill food	
26. Bake food	
27. Fry food	
28. Boil food	
29. Steam food	
30. Heat food	
32. Defrost food	
33. Cool food	
34. Freeze food	
35. Check progress	***50.*** Process-dependent tests
36. Clean utensils and containers	
37. Transfer foods between containers	
38. Set up controls	***51.*** Initialization Uncertainty
39. Dispose of garbage	
40. Stir pots	
41. Add ingredients	

User Functions	Associated Design Factors
42. Prepare sauces	***52.*** Ingredients don't mix
43. Consult recipes	***53.*** Non-linear scaling
44. Prepare servings	

Figure 2. The **Action Analysis** *information collecting form is used to identify* ***Functions*** *for an activity and associate insights, as* ***Design Factors,*** *with them.* ***Design Factor 51,*** *for example, is associated with* ***Function 38.***

Requirement and Insight

The Function Structure is, in a sense, a catalog of requirements for the system. If the system is to perform well, it must fulfill all of the Functions. The design question is, of course, *"how?"* At this point it is important to abandon the old model of the design process as one that proceeds linearly or iteratively through the phases of analysis, synthesis and evaluation. Insight and idea go hand in hand. When insights are obtained, it is crucial to capture the ideas that may follow naturally.

As Activities are described and functions specified in the Action Analysis process, insights are also sought in the immediacy of the moment. On the Action Analysis form (Fig. 2) used to analyze Activities (and develop the information for the Function Structure), there is a section for what are called **Design Factors** juxtaposed to the list of Functions. Design Factors are documents developing insights about Functions. They are titled next to the Function (or Functions) to which they refer.

At this stage of preparation—what would be analysis in the classic model—the creative process begins in the Structured Planning process. The generation of Design Factors forces the interplay of insight and idea at the micro-level associated with individual Functions.

Design Factors

Several features characterize the Design Factor document.

First, a Design Factor is a *document.* It has source and reference information, as well as discussion material and illustrations. Second, it contains information about both *insight* and *ideas.* In one place, the source for ideas and the ideas themselves are recorded. Third, it is *qualitative.* Quantitative information can be incorporated, but the emphasis is on insight, described in the way most appropriate—generally in prose, with mathematical and/or graphic illustrations where useful.

In the Design Factor there resides a model for a corporate or institutional memory associated with the *"why's"* rather than the *"what's"* of project histories. Ideas and the insights that produced them are the diamonds among the enormous amounts of "data dust" accumulated by corporations and institutions. Billions of dollars must be lost every year by corporations that recreate the wheel over and over again because ideas and insights locked in the heads of employees leave with them as they retire or go to other jobs.

A Design Factor (Fig. 3) has two major parts, subdivisions for each, and several reference sections. The first major part is about insight; its two subdivisions are *Observation* and *Extension.* An Observation is a succinct statement of the insight, distilled to its essence—a silver bullet. The Extension fills in the details, examines causes and effects or, less certainly, conditions and tendencies. Essentially unbounded, the Extension section provides a forum for discussion of related information and the exploration of reasons for the Observation. It answers *why* questions as thoroughly as possible.

The second major part is concerned with ideas. It also consists of two sections: *Design Implications* and *Speculations.* Project implications of the insight are drawn here, first, to strategies for solution and, then, to specific concepts. Design Implications are strategic, suggesting directions in which to seek solutions. Speculations are tactical, expressing tangible, concrete ideas that, while still speculative at this early stage of the design process, are well enough formed to be able to be evaluated for how they might contribute to fulfilling any Function.

Figure 3 is a typical example of a Design Factor. Through it we can see how the process distills data into information, explores it for understanding, and then extracts strategies and ideas.

Design Factor | Title: Initialization Uncertainty | 51

Originator	Source/s	Associated Functions
C. Owen	1. Anderson, Robert M. **The Art of Cooking.** London: Acme Press, Ltd., 1973.	**38.** Set up controls
Project: Housing System	2. Keeley, Laura G. *Design Considerations for Cooking Appliances*. **Appliance Technology** 3, No. 4 (April 1989): 47-50.	
Mode: Use (Submode: Food Preparation)		
Activity: Cooking		

Observation

Because of the physical differences in the way heat is produced and applied, it is difficult to know when a cooking device is "ready" at a desired temperature.

Extension

The speed that a cooking device achieves in coming to a desired temperature is partly a function of the heating process and partly a function of the form and material of the cooking vessel. Gas heat is very quickly set; electric heat is very slow to develop -- or dissipate. Ovens require time to absorb heat so that they can come to an equilibrium. Microwaves induce heat quickly in the food. Induction heaters heat cooking vessels quickly (Anderson 1973, 137). In most cases, there is no real indication of the temperature at the moment or the amount of heat being delivered. Ovens are, perhaps, the most reliable in this regard -- particularly if there are means for preventing hot spots (Keeley 1989, 48).

The problem presented is one of initialization. If a measuring system is to use time as its variable, it is important to know when the proper temperature has been reached in order to predict when the food will be done.

Design Implications	Speculations
Sense heat in cooking containers.	**84.** Micro Sampler
Regulate heat by feedback.	**62.** Feedback-Controlled Heating.

*Figure 3. A **Design Factor** records an insight about a **Function.** It also applies the insight to the generation of ideas (**Speculations**) for how to fulfill the **Function.***

The Observation comes from reflection about the Function ***Set up controls.*** This action takes place as food is placed in an appliance for cooking. The essence of the insight is that the application of heat at the right temperature to food is not instantaneous; it arrives at different times and rates depending on cooking process and equipment. The Extension explores this insight with examples of process and equipment and draws some conclusions about establishing initialization times for cooking processes that use time as the control variable.

Design Implications set two strategies for using the insight in a computer-supported food preparation system. ***Sense heat in cooking containers*** suggests building sensing devices directly into the cooking process, in some way allowing the system to read temperatures directly in the food being cooked. ***Regulate heat by feedback*** goes farther to suggest using knowledge of state to vary the rate of heat delivery, thus speeding up the initialization phase as well as stabilizing the cooking process.

For the two Design Implications, there are two specific ideas—Speculations—that might actually be used in the final design. A ***Micro Sampler*** is a probe that can be inserted automatically into a container from within the cooking unit. ***Heat on***

Demand is a procedural idea that places all heating processes in the control of a system director that executes the recipe along with many other food preparation functions.

Manipulative Preparation

As a Design Factor is written, a form of *manipulation* takes place—even though this is still what the psychologists technically would call the *preparation* phase. The separation of the idea part of the document into Design Implications and Speculations generates a tension between *abstract* and *concrete* that may be manipulated.

Paradoxically, as a first step toward an idea, it is almost always better to back away. Rather than directly attempt a solution, it is better to begin from a more abstract position. *"What is a good way to use this information?"* (from the Insight and Extension). *"What different strategies can be employed?"* Almost always, there is more than one way to approach solution—frequently, there are radically different perspectives.

The abstraction ladder runs from general strategy to specific idea. In the middle is the topical strategy. Design Implications in the Design Factor document are topical strategies (strategies specific to the insight at hand); Speculations are specific ideas.

Because general strategies apply to all problems and opportunities, they are good to begin with. They reflect fundamentally different problem-solving approaches. More can always be created because of the richness of natural language, but ten good ones are:

- *Confront the problem*
- *Overwhelm the problem*
- *Avoid the problem*
- *Remove the source of the problem*
- *Circumvent the problem*
- *Isolate the problem*
- *Turn the problem aside*
- *Invert the problem*
- *Divide the problem*
- *Hide the problem*

To develop a Design Implication, a general strategy is chosen and a topical strategy is derived from it. The question is asked, *"What would be a good example of the application of general strategy X to the insight of this Design Factor?"* For our example Design Factor, the general strategy ***Circumvent the problem*** yields the Design Implication, ***Sense heat in cooking containers.*** General strategy ***Overwhelm the problem*** suggests ***Regulate heat by feedback.***

Continuing down the abstraction ladder, the Design Implications are used to generate Speculations. *"What specific idea might result from the application of this Design Implication?"* Speculations are formatted as noun phrases, usually with an evocative adjective or adjective phrase preceding the noun name. Noun phrases are best for conjuring and retrieving images, so they are the choice for denoting ideas. Moreover, the more evocative the description, the more memorable the idea will be. Synectics, Inc. recognized the importance of this early in the development of their techniques for group creativity. Evocative adjective-noun descriptions are called for as "Book Titles" in one stage of their "excursion" procedure for *making the familiar strange.*

> "In form, a Book Title is a two-word phrase that captures both an essence and a paradox involved in a particular thing or set of feelings. The combination of an adjective and a noun is the most workable form" [Prince 1970, 95].

> "The two-word statement to capture the essence with a paradox is not new. Many book titles, not surprisingly, qualify. Originally, we called this step symbolic analogy and thought of it differently. It developed when we asked team members to characterize a thing (like a closure) in a compressed way. To explain what we wanted, we would say 'Pretend you have written a whole book about closures. Think of a two-word, poetic title for your book without the word closure.' One title that would qualify: Penetrable Barrier" [Prince 1970, 138].

Once a Design Implication has been derived and a Speculation invented, the inherent tension in the description system can be exploited. *"What is another way to express the Design Implication?"* (another Speculation from the operative Design Implication). *"What other strategies might be employed to use the insight?"* (other Design Implications). Thoughtful, open-minded manipulation of this tension between abstract and concrete is capable of generating a wealth of specific ideas to fulfill the Function at issue. Generation of the Design Factor and its Speculations at the time of analysis—in the preparation stage—assures the freshest use of the information, at the time it is obtained.

Manipulation

> "Now, with all this material before him—in his mind, on the workbench, or in piles of notes on slips of paper—the creative person begins to try to find some new pattern. he pokes at the material, shuffles it around, turns it upside down, looks at it sideways. ... The manipulative process is an attempt at synthesis, the putting together of hitherto unrelated concepts, and what it hopes to do is 'to make the familiar strange'" [Fabun 1968, 10]

In the Structured Planning process, a major *manipulation* activity is the creation of an *Information Structure* that places Functions together that ought to be seen together *not because they are classified together in predetermined categories, but because they share interest in potential solutions* —the Speculations already invented in large numbers.

If a project has even a moderate number of Functions to be considered, some attempt to organize them will be necessary. The conventional way is to find a set of categories that cover the subject well and assign Functions to them. That is what we do in using Action Analysis to create a Function Structure. For the design of a housing system, this might be the Modes, Activities and Functions revealed through Action Analysis, or it might be traditional and familiar categories such as structural, electrical, plumbing, hvac (heating, ventilating and cooling), etc. Either way, the process is logical, very important in the preparation phase—and *totally wrong for creative synthesis!* Using such a model to organize *design* as opposed to *information collecting* activities virtually guarantees that the only inventive solutions that will cross subject categories will be those that are produced accidentally.

The organization principle needed is one that relates Functions on the basis that they share interest in ideas—no matter in what descriptive category they may fit. Christopher Alexander [Alexander 1964] identified the operative concept. Two Functions are related, or *interact,* for the purposes of design if there is a significant number of ideas that would tend to fulfill both, or there are ideas that would fulfill one, but if used in the final concept, would make it difficult to fulfill the other. Either way, the designer would like to consider these Functions together. In the first case, subtle refinement might make it possible to use a few ideas to fulfill several Functions inventively and elegantly. In the second case, modification of obstructive ideas or selection of alternative ideas might prevent design failures otherwise difficult to foresee.

Computer programs in the Structured Planning process (RELATN and VTCON) enable a design team to create an Information Structure optimized for bottom-up design considerations based on this concept. The RELATN program produces a graph of Functions, using decision data provided by the design team about how the Speculations support or obstruct fulfillment of the Functions (Fig. 4). The VTCON program decomposes the graph to find clusters of Functions that are highly interrelated and, then, clusters the clusters to create an inclusion hierarchy that progressively reassembles the Functions into a structure representing the total project (Figs. 5 and 6).

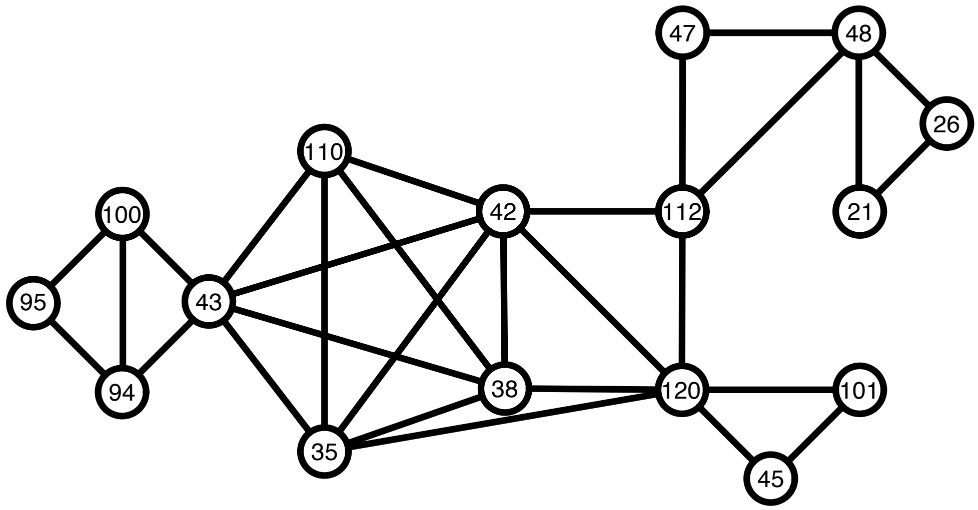

Figure 4. Links determined by the **RELATN** *program relate* **Functions** *(vertices) in a graph. (optimally arranged in this example so that groupings can be seen by inspection).*

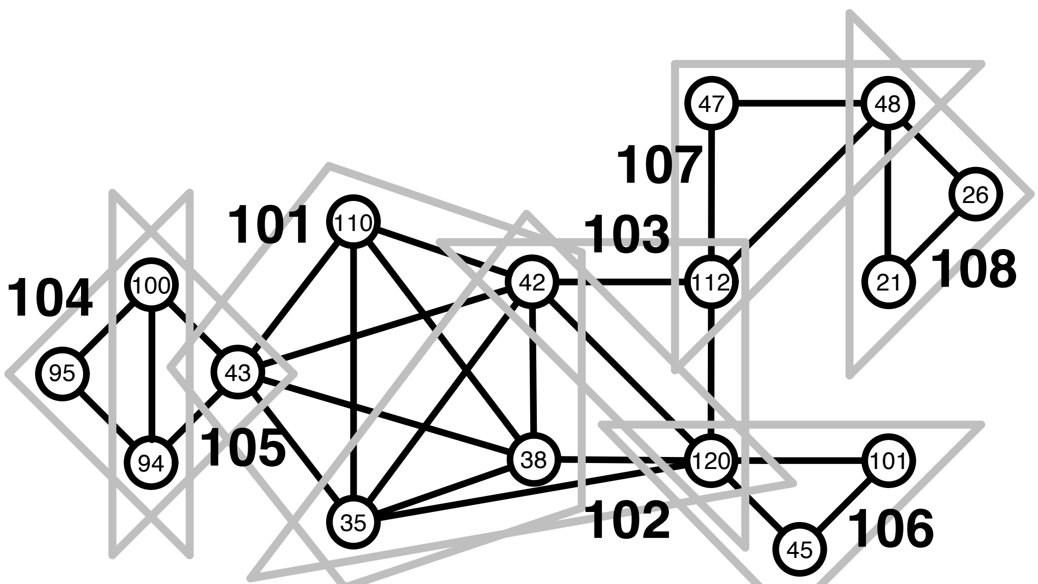

Figure 5. The **VTCON** *program finds clusters of* **Functions** *that are highly interlinked. Cluster notation denotes both level and cluster number (i.e.,* **104** *is level* **1** *cluster* **4***).*

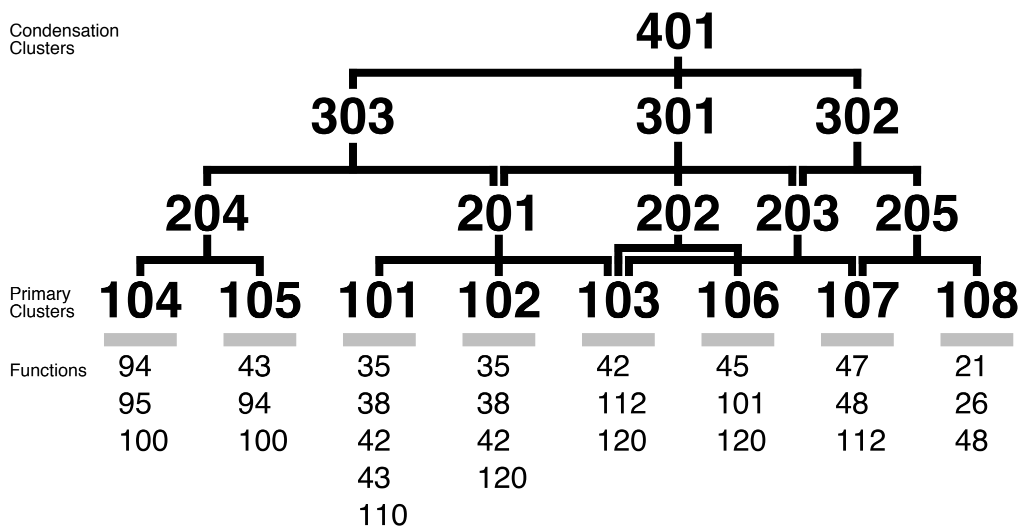

Figure 6. Hierarchical clustering by the **VTCON** *program produces an organization of the entire set of* **Functions***—an* ***Information Structure.***

Setting the View

Other computer programs in the Structured Planning process help to pull together appropriate Design Factors, Speculations and Functions as they are needed in team synthesis sessions. The important thing is that the inspirations for innovative concepts are now where they should be, associated with Functions that should be considered together.

Figure 7 is an example of a second level cluster from an Information Structure constructed for the housing system project. The Functions from three first level clusters are visible. The diagram shows the linkage between the Functions (with the strength of link given on a 0 to 1 scale—indicating the degree of interaction or independence of the Functions with regard to all the Speculations thought of for the project). Shown for each Function also are the Speculations that support (or obstruct) it and the Design Factors associated with it.

While correct in form, this example (like all of the other structural figures) has been purposely simplified for this discussion. Typically, most clusters are larger, and Functions have many more associated Speculations because Speculations invented for Functions not in this cluster may also have been recognized as supporting (or obstructing) these Functions.

The design team uses the Information Structure to organize the synthesis activity. From the juxtaposition of Functions and the concatenation/modification of Speculations conceived over all the information gathering activity, come composite, interesting ideas. Design Factors not only stimulate new ideas through the juxtapositions, but provide bases for evaluation as the new ideas are generated. A flexible, fluid, conjectural/evaluative paradigm for creativity is naturally supported.

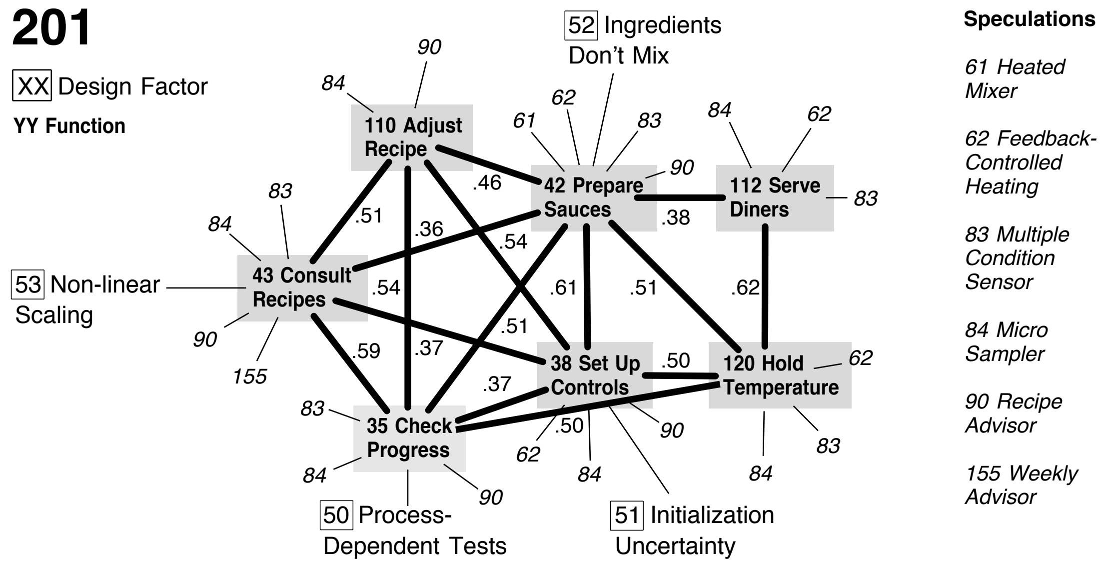

Figure 7. A 2nd level cluster with associated **Speculations** *and* **Design Factors.**

Summary

Contrary to general opinion, creative thinking is not confined to the few. It can be systematically implemented and employed with great success to develop concepts for new products, systems, artifacts and institutions.

The key to successful implementation is integrating insight and idea early in the information collection activity, and then building on that duality as the project develops. The preparation and manipulation stages of the classic creativity model indeed may require Edison's 99 percent perspiration, but treated with a little insight themselves, they make that 1 percent inspiration easy to attain.

In Structured Planning, preparation and manipulation are reconsidered to include specialized idea generating activities. Two important concepts are at the heart of the process. First, insight is critical to creativity, and elements of information must contain both insight and application of insight. Second, the organization of information must support creative reach; things should be considered together that have potential solution together—whatever their conventional classification. Out of strange associations come novel ideas.

References

1. Evans, Bergen. **Dictionary of Quotations.** New York: Delacorte Press, 1968. Evans describes the quote only as being given by Thomas Alva Edison in a newspaper interview.

2. Fabun, Don, Ed. *The World of* $A^n + B^n \Leftrightarrow C!$ **You and Creativity.** Kaiser Aluminum News 25, No. 3 (1968): 9-16.

3. Owen, Charles. **Structured Planning, A Concept Formation Process.** Chicago: Design Processes Laboratory, Institute of Design, IIT, 1988.

4. Prince, George M. **The Practice of Creativity.** New York: Macmillan, 1970.

5. Alexander, Christopher. **Notes on the Synthesis of Form.** Cambridge, MA: Harvard University Press, 1964.