ANALOGICAL ACTS AS CONCEPTUAL STRATEGIES

IN SCIENCE, ENGINEERING AND THE HUMANITIES

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ABSTRACT:

Analogies are used implicitly or explicitly as heuristic procedures for exploring problems, formulating hypotheses, and generating discourse in the arts and the sciences. All of the problem-solving strategies that are commonly used across the disciplines are conceptual models or constructs which operate by means of analogy. By understanding and teaching the problem-solving strategies common to rhetoric and communication courses and by encouraging our students to use the problem-solving strategies that they learn in their own disciplines as heuristic probes to generate the content of their discourse, we can teach them transfer skills while forging an important theoretical link between the conceptual strategies and theoretical models used in the pure and applied sciences, the humanities and composition theory. The purpose of this paper is to identify the composing models which operate by means of analogy, to discuss the importance of analogical acts in the prewriting stage of the composing process, and to explore the relations between analogical acts and concept formation.

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> Writing serves learning uniquely because writing as process-and-product possesses a cluster of attributes that correspond uniquely to certain powerful learning strategies.
>
> --Janet Emig

As teachers and communicators, we all use analogic forms as aids in solving problems and in processing data. Proportional analogies, figurative analogies, archetypes, constructs, metaphors, similes and physical, theoretical and interpretative models are all examples of analogic forms.[1] These forms help us to discover and to communicate what we know effectively and economically to others. A prime reason for the effectiveness of analogic forms as conceptual strategies is that they demand an active--or better yet, interactive--response from the audience. Just as the writer discovers the analogic relations between the subject under investigation and the analogy used to explore it, the audience must rediscover these relations. Our initial cognitive response to a novel analogy is a "synthetic" or "holistic" one: It consists of a novel act of recognition or an illuminating perception of similarity between the analogues. After this initial act of recognition, we call upon our analytical skills to "unpack" the meaning of the analogy and to determine if what initially rang true for us will indeed withstand closer scrutiny. To a degree, this shift from synthesis to analysis and back again is a matter of foregrounding and backgrounding. W. H. Leatherdale describes this process in The Role of Analogy, Model and Metaphor in Science when he states that sometimes one and sometimes another of the analogic relations is brought into focus or juxtaposed with this or that other relation: ". . . sometimes crystallizing out only to dissolve again under the pressure of discordant facts drawn from other areas. . . ."[2]

Our higher level cognitive skills of synthesis and analysis are called into play when we read the following ad that an elite women's apparel shop placed in the St. Paul Chamber Orchestra's program notes: "As Bach is to the fugue; as Mozart is to the divestimento; as Beethoven is to the symphony; so is Peck & Peck to women's clothing. Classical." The relationships set up by this proportional analogy suggest a sense of style, quality and an ambience which go far beyond stating that Peck & Peck specializes in classical clothing for women.[3]

Besides using analogic forms as persuasive and heuristic strategies in advertising, creative analogies serve a very practical informative function in science and engineering. Scientists have long used analogic forms such as the solar system model of atomic structure and the billiard ball model of gas molecules to guide their research and to serve as pedagogical tools. Electrical engineers have also borrowed the language and concepts from a familiar area of knowledge to explore the unfamiliar when they use the language of hydraulics (i.e., the pressure and flow of liquids) to explain voltage and amperage. As these examples illustrate, one of the primary uses of analogic forms for problem-solvers and communicators is to help them to grasp difficult concepts easily by using the familiar as a probe to explore the unknown. Since the analogy that we "import" from a different, more familiar domain to explore the unknown has its laws and properties already well worked out, it provides us with a useful set of categories and attributes that can be used systematically to investigate the subject or problem under consideration. Considering the value of analogic forms as conceptual strategies and discovery procedures, the purpose of this paper is to answer two questions concerning the function of analogic forms: (1) How does the use of analogic forms across the disciplines compare with our use of analogy in teaching composition? and (2) What is the relationship between analogical thinking and learning in general?

II

> Any history of thought might begin and end with the statement that man is an analogical animal.
>
> --S. Buchanan

Analogic forms serve the same descriptive, explanatory and predictive functions in composing that they do in other disciplines. The analogic forms we use in composing help us to arrange information into meaningful patterns and help us to generate or invent the content of discourse. Whenever we use or teach structural or inventional heuristics, we are using analogic forms. In this section of the paper, we will identify thr analogic forms we use in teaching writing and explore how they function in generating discourse.

The composing strategies or heuristic procedures that we teach in composition classroom operate analogically, that is, they set up an analogical rather than a logical relationship between the composing strategy and the resulting discourse. There are two basic types of composing strategies that we teach: (1) structural models, which function primarily to generate the <u>form</u> of discourse, and (2) inventional models, which are used to generate the <u>content</u> of discourse.[4]

Structural Models

Teachers of journalism and technical and professional writing rely very heavily on structural models. These models usually consist of formats or outlines identifying the parts of a discourse and indicating how to sequence the information. Different structural models are used for generating the arrangement patterns for different types of discourse such as the inverted pyramid model for arranging news articles or the causal analysis format for arranging the discussion in troubleshooting reports. Other structural models would include formats for proposals, progress reports and technical memoranda, various types of business correspondence and technical articles. The primary function of structural models is to aid writers in organizing raw data into particular types of written communication. We could schematize the application of structural models to raw data in the following way:

Topic or Problem (raw data)	+	Structural Model (to select, de-select and arange data)	→	Discourse
i.e.,mass of data resulting from a technical investigation	+	structural outline for a technical memorandum	→	the actual technical memorandum

In the case of structural models, the analogic form they illustrate is the direct, proportional analogy. The proportional analogy identifies and explains the formal or structural similarities between the model and the discourse. Since these similarities can be inferred from direct sense experience or from ordinary perception, the structural models make use of what philosophers call "first order properties of direct relation"[5] and set up almost a 1:1 relationship between the model and the discourse. An example of a structural model in science which operates via a proportional analogy is wing : bird :: fin : fish. The relations between the bird's wing and the fish's fin can be easily determined by examining the form and function of these anatomical parts. In composition models, however, the similarities between the structural model and the discourse are even more flexible. When we analyze the discourse into its component parts, the structural model used to generate it becomes apparent. The "purpose statement model" and the following purpose statement taken from Mathes and Stevenson's Designing Technical Reports[6] serve to illustrate the analogical relations between structural models and the discourse:

Purpose Statement Model	Discourse
1. Problem and context	Symmetrically spiraled curves accommodate the natural driving path of the motorist. When properly designed, these curves produce a more comfortable and safer ride. However, engineers have hesitated to use these curves because of the difficulty in
2. Assignment or technical tasks	calculating them. Consequently, the symmetrically spiraled curve program was designed and written to quickly compute
3. Rhetorical purpose	the basic characteristics of the curve. This memo explains how to arrange the necessary data on computer cards so that highway engineers can use the symmetrically spiraled curve program to design a curve (p. 26).

By comparing the model with the sample discourse, we find that the structural model sets up a functional relationship with the discourse. The model describes and explains the arrangement of the information by outlining the component parts of an effective purpose statement. To evaluate a purpose statement that has been previously written or to generate a new statement, we can use the model as a guide and checklist. Used as a guide, the model serves a predictive function, predicting the form of other successful purpose statements.

Since we are dealing with direct relations between the parts of the model and the discourse under consideration, we are easily tempted to teach structural models prescriptively. However, the model is a theoretical construct and its relations to the discourse are analogous rather than logical. Because they posit analogous relations with the discourse, the structural models can only be considered guides to reason or suggested arrangement patterns. In other words, they provide us with heuristic procedures rather than with algorithms.

Inventional Models

Inventional models also operate by means of analogy, but the analogical relations posited here are *resemblances* of relations rather than direct relations of first order properties. Some inventional models, like Rohman and Wlecke's prewriting models, instruct the writer to invent his or her own "suitable analogies" for exploring a problem or topic.[7] In other instances, the writer is presented with specific generative analogies such as the particle-wave-field analogy (drawn from physics) used in tagmemic invention or the dramatistic analogy used in Burke's Pentad.[8] The writer is then instructed to apply these creative analogies as *perspectives* for exploring problems and for generating the content of discourse.

Most inventional models operate by means of esoteric and creative analogies imported from another domain of our experience. These creative analogies must have, as it were, "a life of their own," independent from those properties we are using them to explain. When we employ creative analogies to invent discourse, we import both the analogy and all of its associations from that other domain. The imported analogy together with its complex system of associations provides us with a familiar set of categories and assumptions that we can use as perspectives to aid us in exploring, describing and explaining the "topic analogue," or problem under investigation. We could schematize the application of inventional models to a problem under investigation in the following way:

Topic or Problem for investigation	+	Inventional Model (to stimulate memory, imagination and intuition by discovering positive, negative and questionable analogous relations)

↓

Raw Data, Novel Insights, Unique perspectives	+	Structural Models (to select, deselect and arrange data)	→	Discourse

As this process diagram illustrates, the inventional models are employed prior to and at a different level than the structural models. Instead of setting up a proportional relationship between the model and the discourse (as the structural models do), the inventional models are another step removed. The relationship they set up with the discourse is more abstract and esoteric. The inventional models establish a direct relationship with the writer's cognitive processes (i.e., with his perceptual skills, problem-solving skills, learning skills and verbal skills). In this way, the inventional models guide reason and stimulate intuition to aid the writer in discovering the content of discourse.

To explain the relationship between the inventional models and the writer's cognitive processes, we must explore the process of analogical thinking itself. When the writer applies an inventional model (or creative analogy) to a topic analogue, he is performing what Leatherdale calls an "analogical act."[9] An analogical act consists of a novel act of recognition followed by an examination of the features and properties of the topic under investigation from the perspective of similar features in the inventional model. The analogous relations between these two sets of features can be classified as "positive," "negative" or questionable ("neutral") analogues.[10] The following diagram depicts what occurs during analogical thinking:

Topic or Problem under investigation	+	Inventional Model	-->	Analogical Act (recognition of novel similarities leading to positive, negative and neutral analogues)
i.e., (atomic structure)	+	(solar system model)	-->	

We can explain this process by describing what occurred when Niels Bohr discovered the structural similarities between solar systems and atoms. Bohr used what he already knew about the structure of the solar system as an analogy for relating the isolated facts and speculation then current about the atom. Since the properties of the solar system were directly observable, well worked out and easy to extend and generalize about, he used them as an imported analogy to make the strange and unknown familiar. After his initial illuminating perception of the similarity in structure between solar systems and atoms, Bohr had to work out the implications of these resemblances by identifying and analyzing the positive, negative and neutral analogues generated by this analogical act. When he compared, for example, the solar system's large central sun orbited by planets with the atom's large nucleus orbited by electrons, he identified a positive analogue. The discrepancies in size and physical composition between the solar system and the atom were identified as negative analogues--or areas where the analogy breaks down. Useful creative analogies should enable the investigator not only to identify and explain obvious positive and negative analogues, but also to predict novel similarities based on properties or relations that he has not yet used or that were less apparent initially.

The prediction of new relations, suggested by the imported analogy attest to the heuristic value of the model. For example, since Bohr knew that there is a force called gravity holding the planets in their orbits around the sun, he was led to postulate an analogous force (electrical charges) holding electrons in their orbits around the nucleus.

Such novel prediction, based on the known properties of the model serve as heuristic probes to guide research systematically, rather than haphazardly. The postulated relations are considered "neutral analogues" until, after testing and verification, they can be included as part of either the positive or negative analogues. The usefulness of the inventional model as a conceptual strategy for extending knowledge and discovering new knowledge can be evaluated by the quality of its predictive power or its ability to guide research successfully over time.

Although our discussion of the solar system model of atomic structure is far from complete, it has illustrated that inventional models, operating by means of creative analogies, systematically direct the writer's problem exploration by providing unique perspectives on the problem. The model helps the writer to generate useful data by identifying positive and negative analogues. The questionable or neutral analogues resulting from analogical thinking can aid the writer in forming preliminary hypotheses. As the solar system model demonstrates, the epistemic value of the model is often found in its neutral analogues: while the positive and negative analogues extend our knowledge about the problem, the neutral analogues raise questions which may lead to the discovery of new knowledge. The raw data, novel insights and unique perspectives generated by applying inventional models to puzzling problems enable writers to discover features properties and relations which reformulate their knowledge about the world. Both the structural and the inventional models, therefore, serve as conceptual strategies in problem-solving and communication situations. The question remaining to be answered is: How does the analogical thinking which occurs whenever we apply composing models relate to concept formation and to learning in general?

III

> As philosophy grows more abstract, we think increasingly by means of metaphors that we profess not to be relying on.
> --I. A. Richards

Janet Emig argues brilliantly in "Writing as a Mode of Learning" that writing is a unique mode of learning because of its unique and immediate form of feedback and reinforcement. The information from the process of writing". . . is immediately and visibly available as that portion of the product already written. The importance for learning of a product in a familiar and available medium for immediate, literal (that is, visual) re-scanning and review cannot . . . be overstated."[11] Emig concludes by stating that the process and product of writing share many features with successful learning strategies, and she proceeds to enumerate four of these shared features in her article. Our discussion of the function of composing models in teaching writing and the relationship of these models to cognitive strategies identifies yet another correspondence between writing and learning: the use of analogical thinking as a cognitive strategy for discovering knowledge.

In more poetic terms, Nietzsche recognized the relationship of analogical thinking to discovering knowledge when he described the acquisition of language as a metaphoric (or analogic) process:

> A nerve stimulus, first transformed into a percept! First metaphor! The percept again copied into a sound! Second metaphor! And each time he (man) leaps completely out of one sphere right into the midst of an entirely different one. . . . What therefore is truth? A mobile army of metaphors, metonymies, anthropomorphisms: in short a sum of human relations which became poetically and rhetorically intensified, metamorphosed, adorned, and after long usage seem to a nation fixed, canonic and binding; truths are illusions of which one has forgotten that they are illusions; worn out metaphors which have become powerless to affect the senses; coins which have their obverse effaced and now are no longer of account as coins but merely as metal.[12]

Nietzsche's analysis of the relationship of language to knowledge (truth) leads us to a view of man as an "analogical animal." Man does not deal with ultimate reality--the Thing-in-Itself. "The Thing-in-Itself (pure truth, according to Nietzsche) is . . . quite incomprehensible to the creator of language and not worth making any great endeavor to obtain. He designates only the relations of things to men and for their expression he calls to his help the most daring metaphors."[13] Nietzsche agrees, then, that we are incapable of perceiving Reality. Instead, we create in our minds our own realities, as best we can, based on our capacities to receive and process sensory data and our perceptions concerning that data. In this way, we <u>invent</u> our own realities.

The process of inventing reality is aided by analogical thinking at a very basic level of cognition. When we are faced with a totally new problem or situation, our minds do not know how to recognize or explore the unknown because we have no pre-programmed classification system by which to organize our perceptions. Our ability to perceive something is a learned ability, and we come to recognize and understand the unknown by <u>comparing</u> it to knowledge patterns with which we are already familiar. This search for resemblances between the unknown and the familiar is the crux of all analogical thinking. The pre-programmed or familiar models or procedures which we apply to unknowns in life enable us to discover classification systems to order the positive, negative and neutral analogues between a topic analogue (or problem) and the imported analogy and to make them intelligible. There is a basic correspondence, then, between the analogical thinking employed in successful learning and analogical thinking as a composing strategy.

The importance of analogical thinking to composition and communication stems from its heuristic and epistemic attributes. To explain the epistemic function of analogical thinking, we must understand the memory and logic functions of the brain. The memory function stores information that has been selectively received and selectively translated with structure, meaning and value added to it. The logic function, on the other hand, compares incoming data to stored information and uses this comparison as a basis for determining how to interpret and respond to new data. We can only evaluate new ideas or opinions by comparing them with the ideas and opinions we already have. The more ideas and opinions we become familiar with, the greater is our basis for comparison and for understanding even more. Literally, learning increases our ability to learn more.[14]

The sensory stimulation that we note and respond to becomes processed information. As we evaluate this processed information, we send ourselves internal feedback. It is by the process of getting internal and external feedback on already processed information that we learn. In writing, also, as Emig maintains, the unique and immediate processing of feedback from the portion of the product completed leads to a unique form of learning.

Analogical thinking, operating as part of the "logic" function of the brain, enables us to compare problematic data and unknowns to stored information and to use this comparison as a basis for determining how to interpret and to respond to new data. We could summarize the role of analogical thinking in concept formation and, correspondingly, in the composing process, by noting that analogical thinking involves the perception of novel insights and resemblances. The classification and systematic exploration of these insights, guided by the structure of the imported analogy, brings our problem-solving skills to bear on the data. As we process both internal and external feedback that we get from comparing the unknown with the familiar stored information, we learn. When we attempt to communicate what we have learned in the process, we also involve our verbal skills. To communicate our perceptions, we sometimes even borrow the language of the imported analogy (such as hydraulics) to talk about the topic analogue (electricity) until we either create a new set of terms and concepts (like voltage and amperage) to represent our new knowledge or until we extend the meaning of the old terms (pressure and flow). Therefore, by teaching analogical acts as conceptual strategies for exploring problems and generating the form and content of discourse, we are forging another link between learning and writing to support our contention that writing is a unique mode of learning.

REFERENCES

[1]A more complete listing of analogic forms and a useful discussion of analogy is presented in James R. Wilcox and Henry L. Eubank, "Analogy for Rhetors," Philosophy and Rhetoric, 12, no. 1 (Winter 1979), 1-20.

[2]W. H. Leatherdale, The Role of Analogy, Model and Metaphor in Science (Amsterdam: North-Holland Publishing Co., 1974), p. 15.

[3]For a discussion of the heuristic value of analogy, see Wilcox and Eubank.

[4]The form/content division between these two basic types of models is not entirely clear-cut. A case could be made for inventional models serving somewhat of an arrangement function in certain cases and for structural models serving as guides and checklists thereby helping the writer discover the content.

[5]For a discussion of these properties, refer to Mary Hesse, Models and Analogies in Science (Notre Dame, IN: Univ. of Notre Dame Press, 1970).

[6](Indianapolis: Bobbs-Merrill, 1976), p. 26.

[7]D. Gordon Rohman and Albert O. Wlecke, Pre-writing: The Construction and Application of Models for Concept Formation in Writing (ERIC: ED 001 273).

[8]For a summary of these models, see Richard Young, "Invention: A Topographical Survey," in Teaching Composition: Ten Bibliographical Essays, ed. Gary Tate (Fort Worth: Texas Christian Univ. Press, 1976), 1-43.

[9]Leatherdale, p. 15.

[10]These analogues are discussed at length by Hesse.

[11]CCC (1978), 122.

[12]Friedrich Nietzsche, "On Truth and Falsity in their Extramoral Sense," in Essays on Metaphor, ed. Warren Shibles (Whitewater, WI: The Language Press, 1972), p. 4.

[13]Nietzsche, p. 4.

[14]A. W. Melton, ed. Categories of Human Learning (New York: Academic Press, 1964).