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THESIS APPROVAL

The abstract and thesis of Hartwell S. Francis for the Master of Arts in Teaching English to Speakers of Other Languages were presented September 23, 1994, and accepted by the thesis committee and the department.

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ABSTRACT

An abstract of the thesis of Hartwell S. Francis for the Master of Arts in Teaching English to Speakers of Other Languages presented September 23, 1994.

Title: An Examination of the Occurrences of Metaphor in Introductory Engineering Textbooks.

The aim of this study is to identify the use of metaphor in university-level introductory engineering textbooks. Engineering is an important field of study for foreign students in the United States. In order to determine the linguistic and cultural problems foreign students of this field may have, two introductory engineering textbooks are examined for occurrences of metaphors.

Two corpora of 20,000 words each drawn from introductory textbooks used at two four-year, public universities are examined for occurrences of metaphor. A combined semantic and pragmatic test for metaphor is applied to each word used in the corpora to determine if the use is metaphoric. Each word used metaphorically is given a types-to-tokens ratio to determine if it is used only once or many times. The words used metaphorically are grouped according to metaphor themes and source domains for classroom use.

The types-to-tokens ratios show that many words in the corpora are used only once. Some words, however, are used many times in both corpora. These words include many of the prepositions and words from particularly prevalent metaphor themes and source domains. The results suggest that some concepts such as process, discipline, and time are metaphorically described in English. Knowledge that concepts are metaphorically described is an important explanatory tool for the teacher of English to speakers of other languages.

AN EXAMINATION OF THE OCCURRENCES OF METAPHOR IN INTRODUCTORY ENGINEERING TEXTBOOKS

by

HARTWELL S. FRANCIS

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF ARTS
in
TEACHING ENGLISH TO SPEAKERS OF OTHER LANGUAGES

Portland State University
1994

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CHAPTER I

INTRODUCTION

"The idea that every word has a precise meaning and a fixed denotation is a myth" (Lehrer, 1982:p.xi). Ultimately, this statement by Lehrer underlies this study. The second language learner is often dependent on artificially fixed word meanings in the forms of glosses and dictionary entries. How often do these fixed meanings betray second language learners? How can language teachers make their students aware of this myth? Should they?

Bolinger (1980) describes the meanings of words as lying at varying depths. He adds, "to traverse them is to cross a minefield where every step triggers a silent explosion in the brain" (p.83). The language teacher can help second language learners feel the blast, enable them to bask in the fire of the explosion. Or, these learners can be left blind and unfeeling, perceiving terrific explosions as dull thumps as their dictionaries, oblivious to context and culture, fall shut.

Language teachers should make their students aware of "how words are stretched and twisted" (Harmer, 1991) thereby helping them gain access to the subtleties of the language and the culture they wish to participate in. Recent work in a

variety of fields suggests that metaphor is the blasting cap that language teachers need to set off these meaning explosions for their students.

Metaphor has been found to pervade language. It is "among our principle vehicles for understanding" (Lakoff & Johnson, 1980: 159). It is "a kind of sandwich, with literal, more precise speech lying in between primordial metaphoric language on the bottom and poetic metaphor activity on the top" (Gill, 1986: 224). It is "the only way to say what we mean since the existing semantic fields of current terminology referentially related to the subject in question are inadequate to our own thought" (Martin & Harre, 1982: 95).

It is no surprise, then, that metaphor is often described in modern treatments as ubiquitous; it is an inescapable fact of language, present in the most esoteric scientific research reports and in the pidgin of traders. Yet what little is understood about metaphor has largely been discovered in the last twenty years; and, despite possibly being the most important aspect of language, language teaching techniques that exploit what is known about metaphor have an even shorter history.

BACKGROUND

Metaphor and Linguistics

The trend toward the study of metaphor by linguists and philosophers has caught the attention of applied linguists and

language teachers. Metaphor, novel and conventional, has been found to be pervasive in language regardless of the occasion of use.

Furthermore, metaphor has been found to structure large portions of lexis (Lakoff & Johnson, 1980). For example, the conventional metaphor "arguments are wars" underlies such statements as the following:

(1) His thesis is indefensible.

(2) She attacked several of his arguments.

(3) The examples captured their attention.

Understanding any of these statements requires understanding the lexis of the domain of war and its relationship to the domain of arguments in American culture. Applied linguists and language teachers have recognized the burden widespread, culture-specific metaphor use places on language learners. Recently, they have begun to address the complex issue of teaching metaphor in the language classroom.

This is, however, a recent trend that began in earnest little more than a decade ago with Lakoff and Johnson's (1980) influential book on metaphor. Not until the late 1980s did applied linguists make a connection between metaphoric structuring of lexis and vocabulary instruction (Low, 1988; Nattinger, 1988). Nor did anyone realize the level of need for explicit instruction in metaphor comprehension until long after metaphor had been shown to pervade language. In the 1990s, language teachers (D. Bergmann, 1991, 1992;

Lindstromberg, 1991) began to develop classroom techniques for teaching metaphor comprehension based on the work of linguists and philosophers. In addition, language teachers in English for specific purposes, especially medicine (Ibba, 1991; Salager-Meyer, 1990), began to comb the texts of specific fields to document the use of metaphor.

Unfortunately, this explosion of research and application is not without problems. Definitions of what should count as metaphor are often vague and contradictory. Some researchers even sidestep the issue and proceed by the assumption that metaphor is a known entity and native speakers agree on what is identified as metaphor. The consequences are that metaphor enumerations cannot be compared across studies and studies of metaphor cannot be replicated readily with new texts. It is imperative that any study of metaphor begin with a clear definition of metaphor and a clear statement of the process by which metaphor will be identified.

Because of the complexity of defining and identifying metaphor, much of the following chapter is devoted to these two problems. The definition adopted for the purposes of this paper is drawn from the recent literature in the field of metaphor research. A broad definition is purposefully chosen to take advantage of theorizing that results from such a definition. The section of the following chapter devoted to a discussion of the identification of metaphor is, of course, limited by the definition of metaphor used in this study.

Metaphor and Language Teaching

This study is based on a step suggested by D. Bergmann (1991) and Lindstromberg (1991). D. Bergmann applies the theoretical work of Kittay (1987). Based on her work, he develops a metaphor-based approach to teaching vocabulary in the English as a second language (ESL) classroom. Lindstromberg's work, on the other hand, is an extension of the work of Low (1988). Following Low's step towards applying Lakoff and Johnson's (1980) work to the second language classroom, Lindstromberg argues for a metaphor-based approach to vocabulary instruction in the English for specific purposes (ESP) classroom.

D. Bergmann (1991) concludes "the next step is to select and organize the vocabulary" (p.118) which is to be taught through metaphor-based techniques. D. Bergmann draws his metaphors mostly from newspaper articles although he does draw some from literature and radio. In a more pedagogically oriented paper (D. Bergmann, 1992), he continues to draw his examples from newspapers but also draws many metaphors from television news and sitcoms. He appears to choose conceptually related metaphors used in contemporary texts of great public interest. His goal is to enable his students to recognize metaphors and make educated guesses as to the meaning, or reconstruct the meaning, of metaphors they encounter.

Lindstromberg (1991) pleads for a "field-by-field study

of the role of metaphor in ESP texts" (p.207) to select and organize vocabulary for instruction. Lindstromberg's concern in his article, though, is mostly to publicize the possibility of metaphor as a pedagogic tool and unavoidable fact of language. He, like Low (1988), stresses the need for an explicit treatment of metaphor in the second language classroom. Unlike D. Bergmann or Low, however, Lindstromberg focuses on English for specific purposes. He examines eight truncated texts (average length of 60 words) drawn from economics and science. Although he shares D. Bergmann's goal, his work is more politically charged along the same lines as Lemke (1989), who believes the language of science discriminates against the disenfranchised.

This study stems from these suggestions for further research. In this study, the primary textbooks of two university level introduction to engineering courses are examined. The use of metaphor in these textbooks is documented according to the definition and the processes of identification developed in Chapter II. The metaphors found are then organized for use in the second language classroom. What follows of this chapter is a discussion of other trends in language instruction that have led to this study. The discussion begins with the perceived need to inject content beyond language into the English for academic purposes (EAP) classroom, and it leads to the perception that the field of engineering appears to be an important content area for

learners of English. I conclude that vocabulary and vocabulary learning strategies are key to future academic success of non-native speakers of English (NNSs) and proceed to examine the possibilities of metaphor for vocabulary instruction. This chapter concludes with the questions this study addresses and a restatement of the nature and goals of this study.

Content Vocabulary and EAP

Benesch (1988) advocates infusing English for academic purposes (EAP) with language actually used in content areas to prepare non-native speakers of English (NNSs) for the demands of content instruction in English. The collection of articles she presents is indicative of a larger trend in English language instruction to adapt instruction to the needs of the learners. Benesch's perception of the needs of EAP learners is broad and includes exposing the learners to "the new linguistic, cognitive, social, and cultural demands of studying content in an American college in the target language" (p. 2).

Some of the more specific needs of EAP learners are addressed by Smoke (1988) in the same volume. Smoke documents the learners' own perceptions of their needs through a survey taken one to five years after the learners graduated from English as a second language classes. She found only 18% of the respondents felt that the EAP classes they took prepared them for university course work. The number one difficulty

NNSs reported having was "understanding how to read and study from textbooks" (p. 13).

Benesch's and Smoke's findings that EAP learners need to understand and cope with the linguistic, cognitive, social, and cultural demands of, in particular, content course textbooks, provide further motivation for this study. The problem for NNSs suggested by these findings is the fundamental one of reading for understanding. This problem must be addressed by the second language teacher through classroom techniques that directly benefit the second language learner. Research based on theoretical principles has been conducted concerning approaches to texts, text organization, and background information activation that is applicable to the EAP learner. One important area researchers have underemphasized, however, is vocabulary instruction.

Vocabulary Instruction

Inevitably, vocabulary literature reviews written in the 1980s and into the 1990s refer to the "changes in attitude towards vocabulary acquisition" (Laufer, 1986:69). Meara (1980) was one of the first second language acquisition researchers to notice the lack of research into questions about second language vocabulary acquisition and the organization of a second language lexicon in the learner's mind. These questions, in particular the latter, remain largely unexplored. Indeed, Carter (1987) cites Meara as posing the central unanswered question of concern to

vocabulary acquisition theorists:

> What does a (second language) learner's mental lexicon look like and how is it different from the mental lexicon of a monolingual native speaker? (p.3).

The blame for this paucity of modern research into the nature of the second language learner's lexicon and vocabulary in general is laid at the feet of the Audio-lingual method and its emphasis on a small, structured vocabulary. This limited vocabulary was thought to be necessary to facilitate concentration on the structural aspects of a second language. There would be plenty of time, according to this paradigm, for the acquisition of vocabulary after the hard work of learning the structure of the new language was done.

Since the Audio-lingual method has fallen from favor as the preferred method of teaching a second language, researchers have proposed various approaches to presenting vocabulary. For the most part, these proposals have two similarities. First, there is almost unanimous opposition to the presentation of words in a list or any similar decontextualized, isolated manner. Second, the corollary of the first, words should be presented in contexts rich in association networks across words or in some imageable form of some actual association network (Carter & McCarthy).

The difficulty in these methods has been in their execution; it is simply much easier to present words in lists. In presenting a method of teaching vocabulary, Crow and Quigley (1985) note that most textbooks for learning a second

language in use continue to present vocabulary slated for acquisition in word lists. Carter (1987), in the same vein, laments the lack of texts devoted specifically to vocabulary development and, of those that do exist, he laments that many are not based on linguistically principled descriptions of the lexicon.

The search for innovative techniques for teaching vocabulary according to linguistically principled descriptions of the lexicon has recently generated interest in metaphor as an organizer of lexical items. Nattinger (1988) and Low (1988) have suggested that Lakoff and Johnson's (1980) theory of metaphor can be exploited for vocabulary acquisition. D. Bergmann (1992) reports his successful application of Kittay's (1987) theory of second order meaning to explain conventional metaphor in the second language classroom.

The Field of Study

It is beyond the scope of this study to examine the lexis of more than one field of discourse. Therefore, one field, engineering, has been selected. Until recently, engineering has been the most popular field of study for foreign students at U.S. universities and colleges. In 1989, business and management surpassed engineering as the most popular field of study for these students, but engineering still attracted 18% of their total number. Furthermore, engineering remains the most popular field of study with foreign students who attend

four-year and public institutions (Zikopoulos, 1991). Given the importance of the field of engineering to foreign students, teachers in the English for academic purposes classroom should have at least a rudimentary understanding of some of the language problems these students will face after they leave the EAP classroom.

The needs of all the students of a particular class must be balanced, however; it would be unconscionable to suggest that the language teacher concentrate on the needs of one student out of every five. A focus on the metaphoric use of language used in engineering presents a way out of this dilemma. Short of teaching the actual vocabulary of engineering, such as "resistance" and "slide rule," the ESOL teacher can provide all students, regardless of the fields they wish to study, with strategies for understanding the formation and use of words such as these. Understanding that the meanings of words are often in a state of flux will help students to fix correct meaning based on context.

Furthermore, research concerning metaphor in language suggests that a relatively small number of culture-specific metaphoric concepts organize a substantial amount of language. This vocabulary, then, would appear in engineering texts but would not be limited to them. A study of the use of metaphor in engineering is necessary to determine if these general language metaphoric concepts exist in engineering texts as well as to determine what, if any, engineering specific

metaphors exist in these texts. The results of such investigation can then be used to select vocabulary and develop techniques to teach that vocabulary in the classroom.

RESEARCH QUESTIONS

Based on the brief introduction above, several research questions arise. Once the focus of study has been narrowed to introductory engineering textbooks and the occurrence of metaphors in these textbooks, the metaphors must be documented before they can be organized and before any discussion of classroom applications can take place. The following questions concern the documentation of metaphors in the texts under consideration. The organization and use of the documented metaphors is addressed after these questions have been answered.

1) What is the density, the percentage of the corpora, of metaphors as defined in this study in engineering textbooks?

2) What types-to-tokens ratio of the metaphors is found in the two corpora? Are the same metaphors used again and again?

3) What percentage of the metaphors found in the corpora do each of the syntactic categories of

metaphor make up?

4) What are the observable differences in metaphor use across corpora with respect to questions (1), (2), and (3)?

SUMMARY

Metaphor can be used in the classroom as a pedagogical tool for teaching vocabulary. This tool simply needs to be developed. D. Bergmann (1992) demonstrates the ease with which metaphor can be picked out of the news media for use in the classroom, but important vocabulary and metaphor use that students may face later in their academic careers may be missed. Metaphor use is a language problem and language teachers as a group have a responsibility to know how it is used in the disciplines which are important to their students. Minimal work has taken place with respect to this problem in the language teaching profession despite the anecdotal evidence that metaphor is indeed difficult for second language learners (Voracek, 1987).

LIST OF DEFINITIONS

Domain: A domain is a psychological construct developed to describe the organization of concepts in the mind. Similar and related concepts make up a domain. The domain of dogs, for example, would encompass such concepts as "leash," "dog food," and "kennel." Domain is often synonymous with category and schema.

Metaphor: The use of the terms of one domain to describe another distinct domain.

In this paper, there are three categories of metaphor. Pedagogic metaphors are used to teach; old knowledge is exploited metaphorically to create new knowledge. Theory constitutive metaphors are used to describe scientific phenomenon. Conventional metaphors are used by the culture in which they occur as an integral part of the language. They are once-coined metaphors that have been accepted and are frequently used by the culture in which they occur.

Source Domain: The source domain supplies the concept for metaphoric description of another domain. In

the example, "That child is kept on a short leash," the source domain is dogs.

Target Domain: The target domain is the domain described by a term used metaphorically. In the example, "That child is kept on a short leash," the target domain is human interaction.

Token: A token is any occurrence of metaphor.

Type: A type is a word that occurs as a metaphor. One type can be one or more tokens.

CHAPTER II

REVIEW OF THE LITERATURE

METAPHOR IN SCIENCE

Within English for specific purposes (ESP), Voracek's (1987) teaching experience has taught him that

> technical terms based on metaphor constitute a difficult area with which the advanced ESP student must cope. (p.56)

The difficulty NNSs have with these terms is the motivation behind Ibba's (1991) and Salager-Meyer's (1990) studies of metaphor in medicine. Westerfield (1990) mentions the difficulty NNSs have understanding metaphor produced in spontaneous speech during management lectures and study group meetings. There is no reason given in the literature to suppose that any field is metaphor-free or to assume that NNSs will not have difficulty with the metaphors that occur in these fields.

Black's (1962) work on metaphor and models alerted those who have followed him to the previously unrecognized importance of metaphor to science. Since Black, Boyd (1979) has made an important distinction between pedagogical metaphors and theory constitutive metaphors. Pedagogical metaphors are used to explain science while theory constitutive metaphors are used to expand science. In

addition to the theoretical expansion of science, Butler (1986) notes the use of metaphor in naming parts, denoting actions, and denoting qualities. In the context of this paper, these two broad categories of metaphors will be specific to the field of engineering.

There is a third category of metaphor that must be distinguished from pedagogical metaphors and theory constitutive metaphors. Conventional metaphors embedded in the language of the culture writing about science and technology will occur in the texts of science and technology as well. Furthermore, conventional metaphors will more likely transcend the engineering register.

Pedagogical Metaphors in Science

With all the emphasis the cognitive paradigm places on metaphor, it is no surprise that the use of metaphor as a pedagogical technique is on the rise. There is a trend to consider metaphor as central to the transfer of knowledge which learning often entails. Petrie (1979) finds that "metaphor is one of the central ways of leaping the epistemological chasm between old knowledge and radically new knowledge" (p.440).

Examples of researchers suggesting metaphor be used as an educational tool abound. Duit (1991) and Hewson and Hamlyn (1985) characterize their approaches to metaphor and science as constructivist: "actively employing the already familiar to understand the unfamiliar" (Duit, 1991: p.652). Miller

(1987), in his treatment of metaphor as a pedagogical technique, sets out to "resurrect an educational issue that has lain more or less dormant for several years" (p.219). Pugh, et al. (1992) devote an entire book to the endeavor.

Muscari (1988) urges the use of pedagogical metaphor to structure the domain of science in a way that students can make sense of it based on their more limited experience with science. He states that

> the fact that teacher-science, as compared to student-science, is embedded with utterances that are seemingly cabalistic to a great many students certainly suggests that a consideration of metaphors is hardly beyond the pale of science education. (p.248)

Lemke (1989), who is very much opposed to the cabalistic language of science, cites this use of a pedagogical metaphor:

> (4) Electron comes to town, wants to go into the cheapest hotel. (p.218)

Although Lemke advocates the use of "everyday language" as in (4) to break down the social barriers to science, the pedagogical metaphor (4) nevertheless presupposes considerable cultural and linguistic knowledge.

The increase in interest in pedagogical metaphor will undoubtedly lead to heavier use of such metaphor in the science classroom and in science textbooks. If non-native, and as Bump (1985) and Pugh, et al. (1992) argue, native, English language speakers are to understand these pedagogical metaphors, they must be taught to recognize and understand the transfer across domains that is metaphor.

Scientific Theory and Metaphor

Boyd (1979) argues that metaphors "play a role in the development and articulation of theories in relatively mature sciences" (p.357). His argument is echoed by Martin and Harre (1982), who claim that "the theoretical sciences experience crises of vocabulary" (p.96). Both see the role of metaphor as the basis for the process of catachresis, or the filling of lexical gaps. For example, the terminology of electricity, "current," "flow," "resistance," etc., originated in hydraulic theory, where the phenomena named are much more readily observable.

In science, metaphor is not only used to fill lexical gaps. It is used to describe what is unobservable. For example, Bohr's solar system model of the atom is often cited in the literature. In another example, Muscari (1988) wonders

> whether J.J. Thompson would have ever arrived at his theory of atoms if he had not likened it to a mound of raisin pudding. (p.424)

The purpose of such metaphoric models is to develop testable hypotheses. The Thompson case above leads to questions about how atoms are suspended in space and what, then, is the viscosity of space. These questions are impossible if one knows nothing about raisin pudding.

The metaphor terms of science that are thus created are then refined by the science community (Boyd, 1979). "The metaphor in science places its figures in a public forum" (Muscari, 1988, p.425). This process distinguishes science's

use of metaphor from art's use of metaphor. If the insight gained from metaphor in science proves to be a misapprehension, then the metaphor is discarded.

Miller (1987) seems to believe metaphors disappear once science is able to develop literal terms through hypothesis testing. Because the terminology of the source domain fills the lexical gaps in the target domain discovered and investigated by science, however, the evidence of metaphor remains. New generations of scientists must still learn the science community's understanding of these metaphors (Kuhn, 1979).

Culture and the Language of Science

Hewson and Hamlyn (1985) begin their treatment of cultural metaphors and science by stating that "our conceptual system is grounded in experience, and this is especially true of metaphorical concepts" (p.32). Experience, in large part, is determined by culture. People of different cultures bring different experiences with them when they enter the English language science classroom. They may not be prepared by their experience to interpret science based in an English language culture; they may not understand the domain delimitations and, consequently, the metaphors that cross domains as articulated by this new culture. Hewson and Hamlyn conclude that this has implications for curriculum because for learning to take place "learners must be able to reconcile the scientific view with their existing knowledge" (p.41). Although they found that

the Sotho of Southern Africa conceive of heat metaphorically as "heat is bad," they conclude that the Sotho conception of heat can be reconciled with the orthodox scientific view of heat.

Hewson and Hamlyn's (1985) conclusion, however, is based on learning taking place largely within the Sotho culture. The science teacher, in their scenario, accesses the Sotho domain of heat to explain the science of heat to the Sotho. In an American university, science teachers will not have the time, motivation, or resources to accommodate their curriculum to the various domain conceptions their students may have. Therefore, their non-native English speaking students must be able to rapidly reconstruct their domain conceptions to approximate those of their teachers and texts.

In fact, no student should expect the assistance Hewson and Hamlyn propose; for, as Duit (1991) concludes based on a review of several surveys, teachers and authors

> appeared to presuppose that students were familiar with the analog [the source] domain and would use metaphors, analogies, or similes without any guidance. (p.659)

A DEFINITION OF METAPHOR

In this study a broad definition of metaphor is purposefully adopted. This ensures the inclusion of metaphors that have become so conventional in English that they are often not commonly recognized as metaphors as well as to

include the syntactic variation of metaphor use. The definition adopted comes from a psycholinguistic study of metaphor processing by Trick and Katz (1986).

Trick and Katz (1986) provide the following domain interaction definition of metaphor.

> According to the domains interaction theory, metaphor involves the correlation of two systems of concepts from diverse domains (or categories). (p.186)

Based on a discussion of the metaphor "The Ayatollah Khomeini is a praying mantis," Trick and Katz expand on and explain the preceding definition of metaphor:

> The model works as follows: The domain of the vehicle [the source domain] (insects) serves as a template through which the domain of the tenor [the target domain] (world leaders) is viewed. A common within-domain factor is found that gives a sense of the relative position of the tenor and vehicle within their respective domain. (p.187)

This definition allows for the reanimation of "dead" metaphor and it allows for the syntactic variation of metaphoric usage. Importantly, though, it excludes intra-domain articulations such as lion for the female of the species (Saddock, 1979). Goodman (1968) and Indurkyha (1986) come to the conclusion that the domains need not be separate. This conclusion, however, stems from their inclusion of other tropes, most notably hyperbole, litote, and irony, under the rubric metaphor.

The Domain

A domain is a sphere of influence or activity that is

articulated by a semantic field or fields (Lehrer & Kittay, 1992). For example, Lehrer (1982) cites the domains of "wine" and "instruments for cutting." The domain of wine is articulated in part by a semantic field of adjectives that describe the taste of a wine: {sour, tart, acid, tangy, crisp, lively, etc.}. The domain of instruments for cutting includes {scissors, knife, saw, lawn mower, etc.}. Furthermore, the instruments themselves are domains. The domain of lawn mowers and the domain of scissors contain distinct semantic fields for what is cut: {grass, weeds, flowers} and {hair, paper, cloth}, respectively. Thus, the metaphor for a bad haircut, (5) below, can be analyzed according to a domain interaction definition of metaphor.

(5) Who mowed your lawn?

In this metaphor, the relationship between what cuts and what is cut is transferred to a distinct domain with a similar relationship between what cuts and what is cut.

The term domain corresponds to other similar terms in the literature about metaphor. Researchers refer to systems of associated commonplaces (Black, 1962), implicative complexes (Black, 1979), basic modes of categorization (Winner, 1988), schema (Goodman, 1968), and semantic categories (Cohen, 1979), as well as the more widely accepted domains (Kittay & Lehrer, 1992; Lakoff, 1987), as superordinate organizers of related sets of words. Domain is used in the definition of metaphor in this study because it is the most developed and popular

construct available in the literature.

Semantic Fields

Many researchers appeal to the theory of semantic fields to organize words within a domain. A semantic field is a set of related words organized according to strict relationships such as antonym: {good, bad}; graded antonym: {hot, warm, cool, cold}; cyclical series: {Aries, Taurus, Gemini, etc}.; and parts of a whole: {head, shoulders, legs, feet}. The difficulty of constructing semantic fields for all the words of a domain is exacerbated by the fact that the theory is still in development. As Lehrer (1982: p.18) notes, "no adequate formulation has been given of the notion of semantic fields." Nevertheless, the semantic field is a powerful tool for describing how the source domain structures the target domain.

Given the above mentioned difficulties with the theory of semantic fields, it may be more prudent to conclude that domains have a characteristic set of lexemes, some subsets of which are semantic fields, that can be borrowed to describe other domains.

An example of the use of semantic fields is given here. The very basic domain of spatial orientation contains the antonymic set of lexemes {up, down}. These terms are borrowed to partially describe the domain of feelings as in the following sentences:

(6) They tried to cheer me up.

(7) I'm feeling kind of down.

Not only is the set of lexemes {up, down} transferred but also many lexemes related to this set such as the comparatives "high" and "low," the processes "rise" and "sink," and other terms such as "boost," "lift," "depress," and "fall" (Lakoff & Johnson, 1980).

The domain of spatial orientation is fundamental, perhaps a primitive domain (c.f. Lakoff & Johnson, 1980), because of the nature of the human body and the force of gravity. What target domains are described with terms borrowed from this source domain of spatial orientations, however, has not been shown to be universal.

Conventional Metaphor

Conventional metaphor is distinct from pedagogical metaphor and theory constitutive metaphor in that it is not limited to pedagogy or scientific discourse. Conventional metaphor occurs in a particular culture when a metaphoric description of something becomes widely accepted in that culture. Conventional metaphor permeates language and, as the discussion below demonstrates, conventional metaphor is dependent on culture.

Kuhn (1979) believes that the conventionalized metaphor vocabulary of science loses its established meaning when it is reintroduced to a new generation of scientists. The new generation must reinterpret the conventionalized terms as though they were novel metaphors. With respect to computer

science Johnson (1991) notes that

> those without computer expertise often have difficulty distinguishing between metaphor and reality in computer discourse. (p.273)

The students of science do, of course, benefit from the guidance of the old generation. Thereby, they come to similar conclusions as to the meanings of terms, ensuring the perpetuation of established meaning (Kuhn, 1979).

Based on analogy, one may assume that many conventional metaphors occur for NNSs as literal or as novel metaphors because these metaphors become established in the context of the culture which makes use of them.

This assumption is bolstered by Turner's (1991) discussion of the following metaphor, which is central to the Bororo culture:

(8) We are parrots.

He describes the difficulty non-native Bororo speakers have had interpreting this conventional Bororo metaphor. One early interpreter took the statement literally and concluded that the Bororos had difficulty distinguishing themselves from parrots. Later researchers involve further metaphors such as "parrots are souls" to interpret (8). Turner interprets (8) as a complex interaction of metonymy and metaphor. He refers to the metonymic relationships between feathers and parrots and between atmosphere and environment, and he discusses how these relationships transfer to the domains humans and heaven through the superficially simple statement (8). The Bororo,

on the other hand, have a conventional understanding of what they mean when they state (8).

English speakers, too, arrive at conventional metaphors based on their culture. D. Bergmann (1991) discusses the following metaphor as recently conventionalized:

(9) The conclusion is the bottom line.

This metaphor was coined in the context of an American business culture and adopted and conventionalized by the American English speech community. MacCormac (1985) discusses at considerable length metaphor (10), which underlies numerous conventionalized manifestations of the metaphor (c.f. Gentner & Grudin, 1985):

(10) The brain is a computer.

This metaphor developed in a culture deeply involved in technology.

A further example of a conventional metaphor drawn from Singaporean English cited by Pakir (1991, p.118) demonstrates the opacity of another culture's metaphors.

(11) You try to teach my son la, I tell you, you can cough blood you know.

Pakir translates this metaphor as meaning the education of the son will be a long drawn out illness.

Conventional metaphors like (8), (9), (10), and (11) pervade language. It is these metaphors that have recently attracted the attention of people working in philosophy and linguistics because of their relationship to culture and

thought, because they occur throughout language, and because they are so often unquestioned.

Syntactic Variation in Metaphor Use

Additionally, the definition adopted for this study must include the syntactic variation of metaphoric use (Brooke-Rose, 1958; Winner, 1988). Any syntactic category can be used metaphorically. Too many researchers ignore the syntactic variation of metaphor and choose to focus on only the copula form of metaphor: A is B. The metaphors (12) and (13) of this type, below, have received extensive treatment in the philosophical literature relating to how metaphor is understood:

(12) Juliet is the sun.

(13) The man is a wolf.

This focus limits discussion to questions of how this particular syntactic manifestation of metaphor is understood at the expense of more subtle manifestations.

Psycholinguistic treatments of metaphor also tend to focus overwhelmingly on the copula form of metaphor (Fraser, 1979; Gregory & Mergler, 1990; Keysar, 1989; Shinjo & Myers, 1987; and Waggoner, 1990). This focus on the copula form is a serious limitation of studies of metaphor comprehension (Gregory & Mergler, 1990; Shinjo & Myers, 1987) and of studies that examine the processing differences of interpreting literal and metaphoric language (Keysar, 1989). Focus on the copula metaphor may result from the ease of creating,

identifying, and testing this type of metaphor. With respect to identifying copula metaphors, this form is often most obviously false on literal interpretation.

IDENTIFYING METAPHOR

The Grammar of Metaphor

Lakoff and Johnson (1980) treat the copula form of the metaphor as a prototype or primitive of metaphor. Lakoff and Johnson reduce the other syntactic variations of metaphoric language to one or a small set of copula metaphors. Black (1979) similarly proposes the "metaphor-theme" of the form A as B "as an abstraction from the metaphorical statements in which it does or might occur" (p.25).

In their book, one of the metaphor themes Lakoff and Johnson (1980) focus on is "argument is war." They note that the metaphor "argument is war" pervades academic English discourse. Lakoff and Johnson restate examples (1), (2), and (3) as the copula metaphor "argument is war:"

(1) His thesis is indefensible.

(2) She attacked several of his arguments.

(3) The examples captured their attention.

In (1) the term used metaphorically is an adjective, and in (2) and (3) the terms used metaphorically are verbs. In Black's (1979) terminology, "arguments as war" is a metaphor theme that encompasses all metaphors based on it regardless of

syntactic manifestation.

The organizational power of the copula metaphor justifies its primacy in Lakoff and Johnson's treatment of metaphor, but, as noted above, this does not excuse researchers who focus on the copula metaphor because of the ease with which it is created, identified, and put to test.

Indeed, Lakoff and Johnson (1980) note the difficulty presented by other syntactic classes of metaphors, in this case, the verb metaphors:

> In examples like these [verb metaphors identified by Reddy (1979)] it is far more difficult to see that there is anything hidden by the metaphor or even to see that there is a metaphor here at all. (p. 11)

This is because the source domain of the metaphor must be reconstructed on the evidence of the verb alone; "the verb changes one noun into another by implication" (Brooke-Rose, 1958, p.206).

To understand the verb metaphor, the noun of the domain the verb is associated with must be accessed. Brooke-Rose cites the following example:

(14) You must root out your faults one by one. (p.210)

The noun "faults" is changed by implication to "weeds" although "weeds" is nowhere present in (14).

Metaphor use can be adverbial or adjectival as well as verbal. For example, the adverb "softly" can be used metaphorically , as in (15) below:

(15) She crept softly into the room.

The adjective "high" is often used metaphorically to describe hierarchies, as in (16):

(16) My father is a high level dignitary.

In addition to these types of metaphor, Brooke-Rose's (1958) grammar of metaphor also includes noun metaphor other than the copula metaphor discussed above. When the simple replacement noun metaphor is used, a noun from the source domain stands alone without explicitly being equated with a noun from the target domain. For example:

(17) In case anything happens to the president we should have the spare tire ready.

"The vice-president is the spare tire" must then be reconstructed through context or guesswork. The simple replacement metaphor is often used in science as a method of catachresis (Martin & Harre, 1982).

The simple replacement type of noun metaphor is closely related to the anaphoric reference noun metaphor which Brooke-Rose calls "the pointing formulae." Winner (1988) provides this example of an anaphoric reference noun metaphor used by Shakespeare:

(18) 'Tis an unweeded garden.

The noun from the target domain of (18), the world, was given prior to the utterance of (18) and is referred to anaphorically. Kittay (1987) discusses how the anaphoric noun metaphor can be developed and foreshadowed by exploiting the characteristic words of the source domain that are possible of the target domain or are less obviously

metaphoric.

Finally, what Brooke-Rose (1958) calls "the genitive link" metaphor includes metonymic relationships. Brooke-Rose formulates this metaphor as follows.

> B is part of, or derives from, or belongs to or is attributed to or is found in C, from which relationship we can guess A, the proper term. (p.25)

She discusses this example:

(19) the hostel of my heart.

The metonymic relationship of the source domain, "a boarder is an inside part of a hostel," corresponds to and is transferred to the target domain metonymic relationship, "the heart is an inside part of the body." Further application of pragmatic knowledge, knowledge of what boarders do, leaves the reader wondering when the heart will check out and where it will go.

Absent from Brooke-Rose's (1958) grammar of metaphor is the metaphoric use of place prepositions. Place preposition metaphor is well documented by Lakoff and Johnson (1980) as demonstrated by their frequent reference to copula metaphors of the form "X is a container," which stems from the metaphoric use of "in." Quirk, et al. (1985, pp.685-687) and Greenbaum and Quirk (1990, p.196) provide a clear and succinct taxonomy of place preposition metaphors. Their discussions, however, consist mostly of examples of place prepositions used metaphorically and example choice varies in these discussions.

Quirk, et al. (1985) are criticized by Cooper (1986) for the looseness of their discussion and even their willingness

to consider place prepositions as metaphors: "this runs so counter to our ordinary talk about metaphor, vague as it is, that it is hard to take seriously" (p.122). Given the controversy, any place preposition not used in its locative sense will be considered metaphoric in this study.

To give some idea of the metaphoric use of place prepositions, a list of examples developed by Quirk, et al. (1985, pp.685-687) is provided here. Their list is as follows: "in" used with non-containers or for abstract inclusion: in a process; "in/out of" used with a state or condition: in disarray, out of my mind; "into/out of" used with an abstract condition or circumstance: into baseball cards, out of trouble; "above/below/beneath" used with an abstract hierarchy: above suspicion, below freezing, beneath contempt; "in/on" used with membership or participation: in engineering, on the board; "under" used with a process: under construction; "up/down" used with movement on a list or scale: up the social ladder, the temperature went down; "from/to" used with originator and recipient: from me to you; "beyond/past/over" used with an abstract noun: beyond redemption, past his prime; "between/among" used with an abstract relationship between participants: a secret between friends; and "through" used for perseverance or endurance: go through with it. The preposition "up" used to indicate completion should also be included in this list (Lakoff & Johnson, 1980).

Linguistic Identification of Metaphor

Black (1979) is skeptical that metaphor can be conclusively distinguished from literal language: "every criterion for a metaphor's presence, however plausible, is defeasible in special circumstances" (p.36). However well-founded Black's skepticism, some linguistic criterion of what is metaphoric use of language must be established for the purpose of this study.

A definition of metaphor and a grammar of metaphor are not enough to document the presence of metaphor in texts. Some linguistic process of identifying metaphor must be included as well. The process of identification must be made explicit if a study of metaphor in texts is to fulfill the requirement of replicability. Three approaches to the identification of metaphor have been taken in the literature: a semantic approach, a pragmatic approach, and a combination semantic and pragmatic approach. The latter approach is taken in this study.

The Semantic Approach. The semantic approach begins with Katz and Fodor's (1963) componential theory of semantics. According to this theory, a lexical item can be decomposed into lexical features that determine whether or not the item can be selected for use in a given context. A lexical item used metaphorically would violate one or more of the selectional restrictions imposed by the features of the item. For example, "moon" in (20) below is [-ANIMATE] and therefore

cannot be described as pregnant, which takes a [+ANIMATE] subject.

(20) The moon is pregnant tonight.

Following a strict Katz-Fodor theory, any sentence in which a term used metaphorically violates a selectional restriction is considered anomalous and cannot be interpreted (Lowenberg, 1975). This flies in the face of common sense and has led to the adaptation of Katz-Fodor semantics to account for metaphor.

Cohen's (1979) semantic treatment of metaphor is based on Katz-Fodor semantic theory. According to Cohen, a semantic theory must account for the metaphoric use of language because "novel" metaphors become conventional metaphors. Furthermore, a once-novel metaphor can lose its original meaning completely (D. Bergmann, 1991). Cohen proposes a semantic feature-cancellation rule that functions to prevent anomaly by canceling the specific features of the vehicle that cause anomaly. For example, in (21) below, drawn from Cohen's article, the feature [+AMBULATORY] is deleted from "limps:"

(21) Otherwise their theory limps. (p.66).

Cohen admits that no principles controlling feature-cancellation have been formulated. He suggests the features of a lexical item be ordered according to importance determined by the saliency of the features. The most salient features, what Cohen calls the empirical features, of the vehicle are then canceled through metaphoric use of language.

The Pragmatic Approach. A purely semantic account of metaphoric use of words, however, cannot explain the target domain articulation proposed in the definition above. Pragmatic knowledge is essential to identifying and interpreting metaphor. Cohen's (1979) proposed feature-cancellation rule does not account for the transfer of within domain relationships, such as the relationship between what cuts and what is cut in example (5) above. Cohen focuses on the level of specific concepts related in metaphor and ignores the level of semantic domains of those concepts (Kelly & Keil, 1987). In Gentner's (1982) terminology, Cohen focuses on the transfer of object attributes, the one place predicates, and ignores the transfer of relationships, the relational predicates. The semantic field relationships can be transferred from the source domain to the target domain with one word, as in the genitive metaphor (19) above.

Understanding metaphor goes beyond knowing the terms used metaphorically to knowing how those terms fit within their respective domains. In a study in which subjects related periodicals and food, Kelly and Keil (1987) found that

> when a person comprehends a metaphor relating two domains, the similarity between the tenor and the vehicle increases. More important, however, is the finding that metaphor produces an increase in similarity between other concepts from the same domain as the tenor and the vehicle. (p.46)

Consequently, the relationships between the words of the two domains were preserved: "The New York Times is a steak" led to "The New York Post is a hot dog." These examples show, as

well, that knowledge of the world, or more specifically, cultural understanding of the world in which the Times and the Post are embedded, is required to understand metaphor.

Indeed, metaphor is often dependent on culture and shared experience. Example (11) above, drawn from Singaporean English demonstrates the opacity of another culture's conventional metaphors. When the metaphor is explained, significant cultural differences are suggested. To produce metaphor (11), illness in Singaporean culture must be a less taboo subject than in American culture. To understand metaphor (11), pragmatic knowledge is essential.

Additionally, the saliency criteria Cohen (1979) proposes are untenable without recourse to pragmatics. The semantic features of a word can not be organized hierarchically given that context often determines the saliency of the features of words used metaphorically (M. Bergmann, 1991). The componential theory of meaning Cohen ascribes to is based on a metaphorical conception of words as containers that hold meaning. This contrasts with a relational theory of meaning that words mean only in relation to other words, a theoretical approach more akin to pragmatics than to semantics and a necessary one to explain metaphor (Kittay, 1987).

Reconstructing Metaphor. Finally, to identify conventional metaphor as metaphor, what Kittay (1987) calls the first order meaning must be reconstructed by what Cohen (1979) calls the diachronic word knowledge of the competent

speaker of the language. The process of conventionalization may be, as D. Bergmann (1991) believes, pragmatic, tied to communicative goals, but the reanimation of a conventional metaphor rests on its semantic transparency as a metaphor. If the words used metaphorically, however conventional this use has become, are perceived as originating within the context of another domain by a speaker familiar with the relational and semantic meaning of the words, then the metaphor can be reanimated, the prior literal sense can be recovered. For this reason more than any other, place prepositions not used in their locative sense are said to be used metaphorically in this study.

This reanimation then allows for the (abstract) replacement of the words used metaphorically to their original domain, and, subsequently, analysis of the metaphor. For example:

(22) Leg of the table

is often cited (Kittay, 1987; Richards, 1936) as a conventional but transparent metaphor. That is, it is clear that the word leg, which refers to an anatomical organ, is being used to describe something inanimate.

In another example, (23) below, branch is used as a simple replacement metaphor.

(23) Engineering is a branch of science.

This is a case of catachresis in that it is unclear what term branch replaces. The word branch, however, literally arises

in the contexts of trees and has long been used metaphorically to describe rivers. Interestingly, the term could have been borrowed from the domain of flora, in which branches are dependent on and grow from the stem or trunk, or from the domain of rivers, in which branches feed and cause to swell the river.

For Cohen, this knowledge of the prior literal sense of words is diachronic word knowledge. For Kittay (1987) and D. Bergmann (1991) this knowledge is awareness of the first-order meaning of words. For Lakoff and Johnson (1980) this is knowledge of the experiential basis of words: we see that both trees and rivers have branches.

Lexical Competence. Diachronic word knowledge, first-order meaning awareness, and experience are problematic concepts. As D. Bergmann (1991) notes, "the first-order meaning will vary according to individual knowledge and experience" (p.68). Such variance leads to Lindstromberg's (1991) inclusion of Greek and Latin words used in English in his definition because of his knowledge of their morphology and literal translation. D. Bergmann, however, excludes Greek and Latin words from his definition because of his conviction that a majority of the English language speech community does not possess this knowledge and is not using it when those words are used.

This paper follows D. Bergman (1991) with respect to Greek and Latin words. Indeed, for the purpose of teaching

English as a second language, recourse to the Greek and Latin origin of many English words that might be construed as metaphorical in Lindstromberg's (1991) discussion will cause more harm than good. Consider, for example, the word "employ." A definition based on the Latin origin of this word would produce to enfold. It is more difficult to explain the metaphor than it is to define the word as it is now used with a simple gloss or some examples.

The discussion above can be considered in light of Richards' (1976) description of lexical competence. Among other things, the native speaker's knowledge of a word includes knowing the limitations of the use of that word according to function and situation, knowing the many different meanings associated with that word, and an awareness of the network of associations between that word and other words. The lexical competence of the native speaker should be adequate for judgements of metaphoricity in terms of diachronic word knowledge, first-order word meaning awareness, and experience.

SUMMARY

For the purposes of this study, the definition of metaphor and the semantic and pragmatic processes for identifying metaphor are the crucial information from the literature review. The definition of metaphor is repeated here.

> Metaphor involves the correlation of two systems of concepts from diverse domains (or categories).

The broad scope of the definition allows the inclusion of conventional metaphor and it does not emphasize one syntactic manifestation of metaphor over any other. Examples of the syntactic manifestations are listed below:

Noun:
- copula: man is a hamster
- simple replacement: the third step in a process
- anaphoric reference: this point is crucial
- genitive: the heart of the computer

Verb: the idea emerged

Adverb: widely known

Adjective: a high temperature

Preposition: in making a kite

From semantics, the process of determining the literal falseness of a sentence by examining the selectional restrictions of the component words allows the automatic identification of most metaphors. Context provides the means of identifying those metaphors which are not literally false. For conventional metaphor, through diachronic word knowledge, including cultural knowledge and experience, a competent speaker can access the first order meaning of words to identify them as metaphoric.

CHAPTER III

METHODOLOGY

DESIGN

Size of the Corpus

Brady (1991) reviews the selection of corpus size in the TESOL literature. He comes to the conclusion that 8 to 10 thousand words is the minimum length for an adequate corpus and 25,000 words will assure sound results. Finding an occurrence of under 1% of his corpus to be two part verbs, Brady increased the size of the corpora he studied to 36,000 words to ensure stability and validity.

In a study of metaphor in medical texts, Salager-Meyer (1990) examined three corpora of 45,000 words. Her findings of just over 1% of her corpora to be occurrences of metaphor are approximately equal in magnitude to Brady's finding for two part verbs.

Based on Salager-Meyer's study, it is tentatively assumed that occurrences of metaphor will comprise 1% of the engineering corpus. Following the precedence set by Salager-Meyer and the research into corpus size of Brady, two corpora of 20,000 words each will be examined. This total, then, is an engineering corpus of 40,000 words.

Nature of the Corpora

Two corpora drawn from the primary textbooks of introductory engineering courses at two public four-year universities are examined.

(1) The Eide Corpus: This corpus is drawn randomly from Engineering Fundamentals and Problem Solving written by A.R. Eide et al. and published in 1986 by McGraw-Hill, Inc. The following are objectives of the book as stated by the authors:

> (1) to motivate engineering students in their first year, when exposure to engineering subject matter is limited; (2) to provide them with experience in solving problems (in both English and SI units) and in presenting solutions in a logical manner; (3) to introduce students to subject areas common to most engineering disciplines, areas which require the application of fundamental engineering concepts; and (4) to develop their basic skills for solving open-ended problems through a design process. (pp. ix-x)

The book is arranged in chapters each followed by a problems section. The problems sections will not be included in the corpus. For a sample of the corpus see Appendix A.

(2) The Burghardt Corpus: This corpus is drawn at random from Introduction to the Engineering Profession written by M.D. Burghardt and published in 1991 by HarperCollins Publishers, Inc. The author states the objectives of the book as the following:

> [This book] is to interest and excite students about the various opportunities afforded by engineering education: the creative challenge and reward of engineering design, the use of analytic skills in problem formulation and solution in engineering and management, and the skills and attitudes necessary for a rewarding and stimulating college education and for a career after

graduation. (p. xii)

This book is also arranged in chapters followed by a problems section. The problems sections will not be included in this corpus. For a sample of the corpus see Appendix B.

METHOD

Metaphors, as defined in the previous chapter, were identified and recorded in both corpora in order to document the use of metaphor in engineering. Metaphors were identified according to the definition of metaphor selected for this study. The two processes used to identify metaphor were a check for semantic anomaly and the application of the pragmatic knowledge of the native speaker. Both processes rely on Richards' (1976) definition of the lexical competence of the native speaker of a language. An interrater reliability test was included in the data collection process.

The interrater reliability test consisted of a corpus of 4,000 words, 10% of 40,000, drawn in equal portions from the two corpora under study. The secondary rater looked for instances of metaphor according to the interrater guidelines given in Appendix C. In addition to the guidelines sheet, the secondary rater was given detailed instruction by the primary rater regarding the use of metaphor and the definition of metaphor used in this study. This instruction included an analysis of one page of text drawn from the corpus by the primary rater for the benefit of the secondary rater. Further

explanation was given to the satisfaction of the secondary rater.

The secondary rater scored the interrater reliability corpus by circling all instances of metaphor. A scored page of text drawn from the interrater corpus appears in appendix D. The metaphors found by the secondary rater were compared with those found in the same corpus by the primary rater. This comparison resulted in an interrater reliability agreement percentage. A high percentage indicates replicability while a low percentage indicates the identification of metaphor is subjective.

In this study, a university educated female secondary rater was employed. The secondary rater's credentials include an RSA certificate in teaching English as a second language, experience teaching English, and several classes in linguistics. The interrater agreement for the interrater corpus was 0.67. The possible causes of this low interrater agreement are discussed in the section on the limitations of this study below.

The two corpora under study were examined by the primary rater with the goal of answering the four research questions listed in the first chapter. The questions are repeated here:

1) What is the density, the percentage of the corpora, of metaphor as defined in this study in the engineering textbooks?

2) What types-to-tokens ratios of the metaphors are found in the two corpora? Are the same metaphors used again and again?

3) What percentage of the metaphors found in the corpora do each of the syntactic categories of metaphor make up?

4) What are the observable differences in metaphor use across corpora with respect to questions (1), (2), and (3)?

In answer to research question one, the metaphors of both corpora were collected and the percentage of each total corpus that are metaphors is determined. The metaphor percentage of each corpus was determined by dividing each total corpus by the number of metaphors collected from that corpus and multiplying the quotient by 100.

In answer to research question two, for each corpus the total number of metaphors found in the corpus (tokens) was divided by the number of occurrences of a particular manifestation of a metaphor (type) and each quotient so obtained was then multiplied by 100. In other words, the number of metaphor tokens were divided by each metaphor type and the quotient was multiplied by 100. This produced a types-to-tokens ratio for each particular occurrence of metaphor.

In answer to question number three, for each corpus the tokens and types were then separated into the syntactic categories discussed in the literature review above. These categories are copula nouns, simple replacement nouns, genitive nouns, anaphoric reference nouns, verbs, adjectives, adverbs, and place prepositions. The percentage of each category of the whole was determined by dividing the number of occurrences in each category by the total number of occurrences in the corpus and multiplying the quotient by 100.

Finally, to answer question four, the two corpora were compared with respect to the three preceding research questions. The graphs and ratios produced in the process of answering questions one, two, and three are contrasted in a discussion of the observable similarities and differences of the use of metaphor in the two corpora.

Following the comparison in answer to research question four, the metaphors found in both corpora are discussed in depth and organized into coherent systems. It is hoped that this discussion and organization will be of use to the classroom teacher of the English language.

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS

The metaphors occurring in the two corpora are found in Appendices E and F. Appendix E lists the words used metaphorically in the Eide Corpus. Appendix F lists the words used metaphorically in the Burghardt Corpus. The words are grouped according to the syntactic categories outlined in the literature review section. Each word appears with its types-to-tokens ratio.

Based on the interrater reliability test, it seems that the process of identifying metaphors is somewhat subjective. Interrater agreement for the interrater corpus was 0.67. Differences in domain conceptions between the raters is the major factor for the low interrater agreement score. This finding is discussed in detail below as a limitation of the study.

Density of Metaphor in the Corpora

In answer to research question one, the total occurrence of metaphor in each corpus was divided by the total number of words of each corpus and the quotient was multiplied by 100 to

produce the density of metaphor for each corpus. The resultant densities of metaphor can be used to compare this study with other studies of the occurrences of metaphor.

In the Eide Corpus, 913 words were found to be used metaphorically. Given a total corpus size of 20,000 words, this produces a density of metaphor of 4.56%.

In the Burghardt Corpus, 952 words were found to be used metaphorically. Given a total corpus size of 20,000 words, this produces a density of metaphor of 4.76%.

The metaphor densities, the percentage of words used metaphorically of each total corpus, are displayed graphically in Figure 1 below.

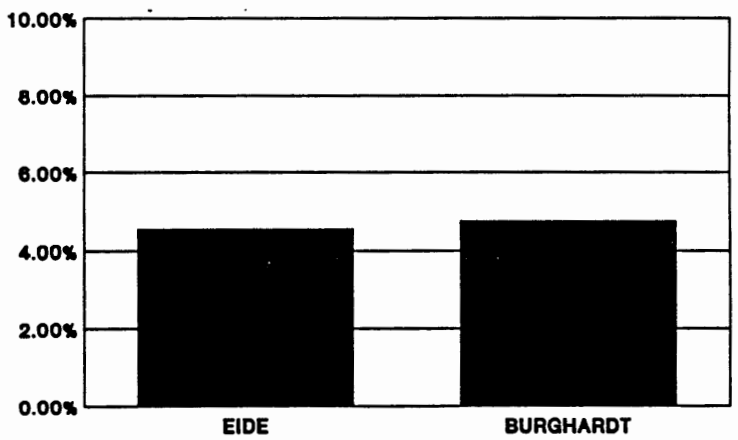

Figure 1. Density of metaphor in Eide and Burghardt corpora.

If the two corpora are combined, the total number of words used metaphorically is 1,865 in a corpus of 40,000 words. This produces a density of metaphor of 4.66% for the

combined corpora.

Types-to-Tokens Ratio of Metaphor in the Corpora

In answer to question two, the occurrence of a type, a particular manifestation of a metaphor, in each corpus was divided by the total number of tokens, the total number of occurrences of metaphor, in the corpus in which it occurred. The quotient was multiplied by 100 to produce the types-to-tokens ratio for each token. The types-to-tokens ratio for each word used metaphorically appears with the word in Appendices E and F. These ratios can be used to compare this study with future studies of the occurrence of metaphor.

There were 243 types in the Eide Corpus. Only 13 words in the Eide Corpus had a types-to-tokens ration of 1.00 or greater. A total of 138 words in this corpus had a types-to-tokens ratio of 0.11. In other words, 57% of the words used metaphorically in the Eide Corpus occurred only once.

There were 280 types in the Burghardt Corpus. Only 12 words in the Burghardt Corpus had a types-to-tokens ration of 1.00 or greater. 169 words in this corpus had a types-to-tokens ratio of 0.11. In other words, 60% of the words used metaphorically in this corpus occurred only once.

Syntactic Categories

In answer to question three, the data can be broken down into syntactic categories in two ways. First, the total for each category can be determined by counting the number of

tokens in each category. Second, the total for each category can be determined by counting the number of types in each category. Each corpus is discussed below according to these divisions.

The Eide Corpus. Division of the Eide Corpus into categories by tokens produces 41% prepositions, 34% nouns, 11% adjectives, 12% verbs, and 2% adverbs. The results of this division are shown graphically in Figure 2 below.

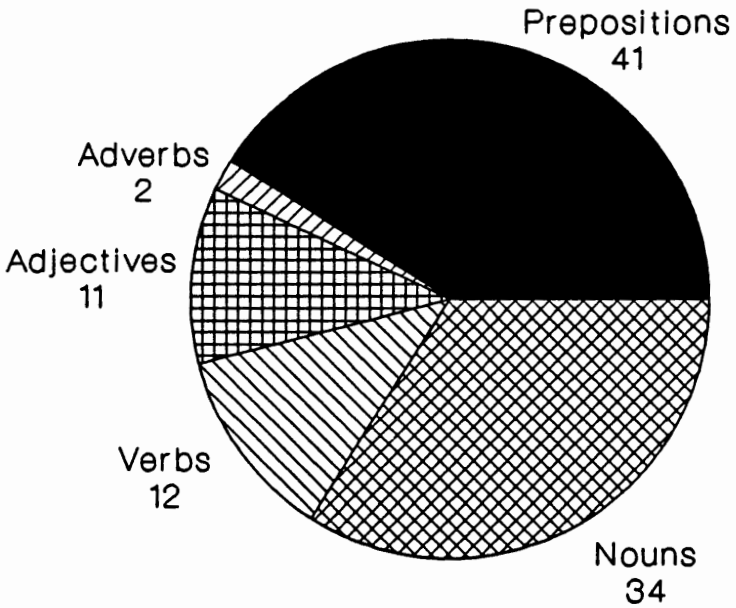

Figure 2. Division of Eide corpus into syntactic categories by tokens.

The noun category can be divided further into the four categories of noun metaphor. By tokens, this division produces 91% simple replacement nouns, 5% genitive nouns, 4% nouns used in anaphoric references, and 0% nouns used in a copula. These results are shown in Figure 3 on the following page.

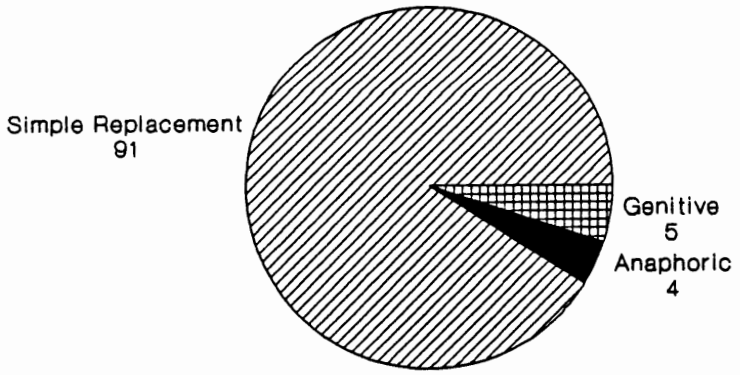

Figure 3. Categories of nouns in the Eide corpus by tokens.

Division of the Eide Corpus into syntactic categories by types produces 41% nouns, 25% verbs, 19% adjectives, 7% prepositions, and 8% adverbs. Figure 4 shows these results.

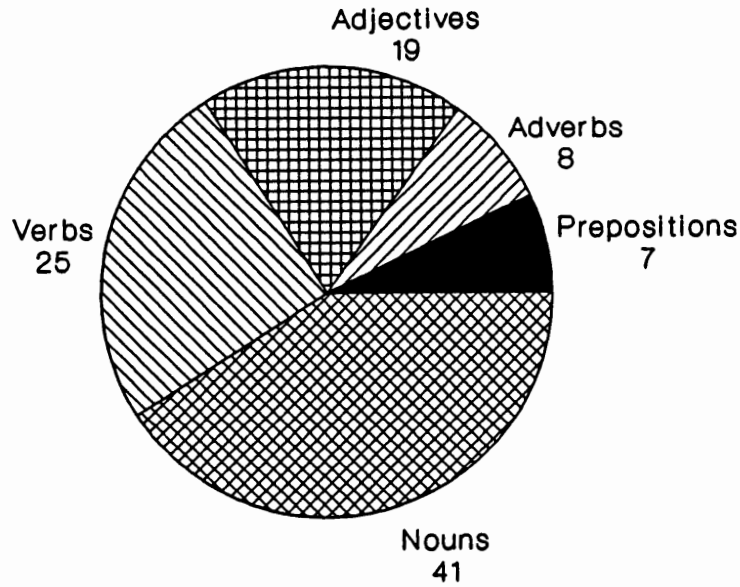

Figure 4. Division of Eide corpus into syntactic categories by types.

A comparison of Figure 2 and Figure 4 shows a dramatic

drop in place prepositions as a percentage of the total. This drop is explained by the large types-to-tokens ratio of the prepositions as a class. A few prepositions, most notably "in" and "on," were used much more frequently than any other type in the corpora.

This comparison between Figure 2 and Figure 4 also highlights the jump in percentage shown by the syntactic classes of adjectives and verbs. Again, the types-to-tokens ratio for these two classes explains this jump. Adjectives and verbs as tokens were much more likely to occur only once in the corpora.

The Burghardt Corpus. Division of the Burghardt Corpus into syntactic categories by tokens produces 42% prepositions, 34% nouns, 14% verbs, 9% adjectives, and 1% adverbs. These results are shown in Figure 5 below.

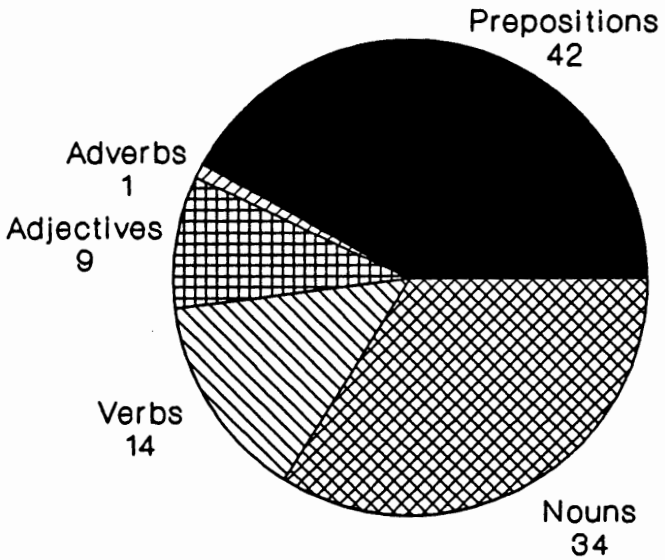

Figure 5. Division of Burghardt corpus into syntactic categories by tokens.

If the noun category of the Burghardt Corpus is divided by tokens into the four categories of nouns the results are 77% simple replacement nouns, 12% genitive nouns, 10% nouns used in anaphoric reference, and 1% nouns used in a copula. Figure 6 below shows this division.

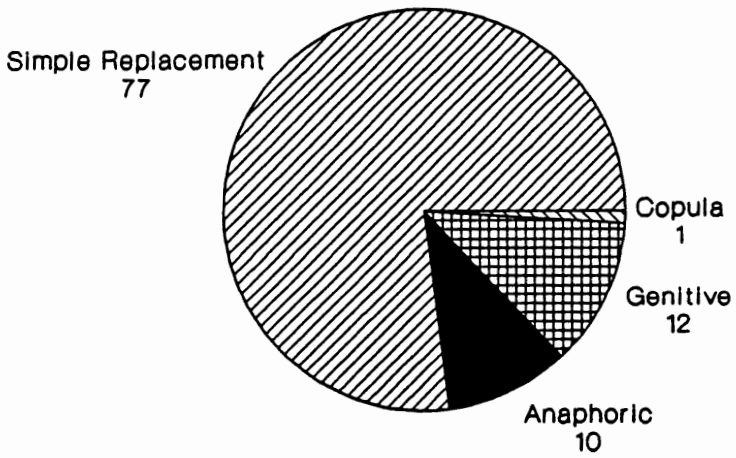

Figure 6. Categories of nouns in the Burghardt corpus by tokens.

Dividing the Burghardt Corpus into the syntactic categories according to types produces 47% nouns, 29% verbs, 17% adjectives, 5% prepositions, and 2% adverbs. These results are shown in Figure 7 on the following page.

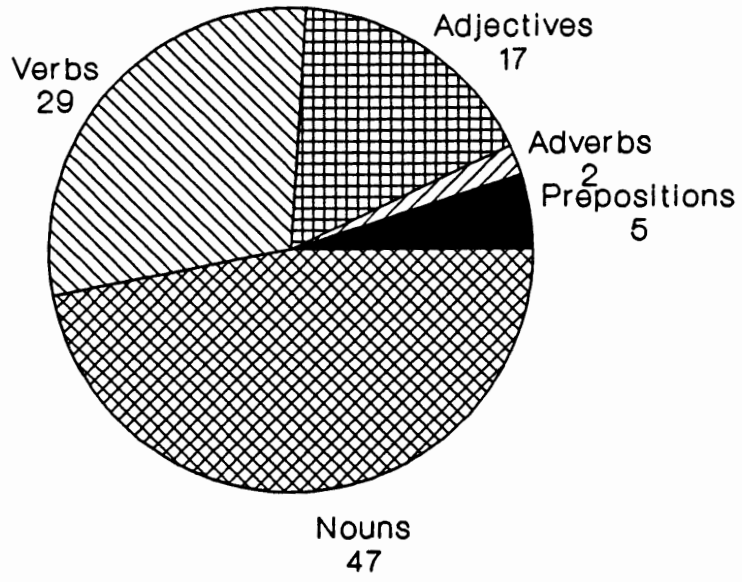

Figure 7. Division of Burghardt corpus into syntactic categories by types.

Figure 5 and Figure 7, which illustrate the Burghardt corpus, show the same tendency that Figure 2 and Figure 4 show for the Eide corpus. The prepositions make up a large percentage of the graph in Figure 5 but a small percentage in Figure 7. For the syntactic classes of adjectives and verbs, the reverse is true.

Comparison Across Corpora

The density of metaphor in both corpora is nearly the same. The percentage of words used metaphorically in the Eide corpus is only 0.20% less than the percentage of words used

metaphorically in the Burghardt corpus. The percentage in both corpora is much higher than the roughly 1% metaphor density for medical texts reported by Salager-Meyer (1991).

Furthermore, the distribution by syntactic categories according to tokens and types was roughly the same across corpora. The only notable difference being the somewhat heavier metaphoric use of place prepositions and adverbs as types in the Eide corpus.

Finally, the metaphor types found in each corpora were not the same. The Venn diagram in Figure 8 shows the overlap by type between the two corpora.

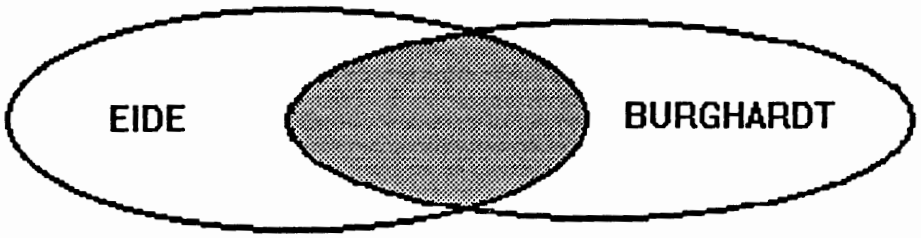

Figure 8. A Venn diagram depicting the overlap of metaphor types in the Eide and Burghardt corpora.

Forty percent of the types in the Eide corpus were also found in the Burghardt corpus. Thirty-five percent of the types in the Burghardt corpus, the corpus with more types, were found in the Eide corpus. The closed syntactic category of place prepositions showed the greatest overlap with 100% of the place prepositions occurring in the Burghardt corpus also occurring in the Eide corpus.

DISCUSSION

This section begins with a discussion of the metaphors by syntactic category. The paucity of copula metaphors is addressed and then the syntactic classes of prepositions and adjectives are discussed. Finally, many of the metaphors found in the corpora are discussed according to the domain interaction definition of metaphor.

To organize many of the metaphors found in the corpora, two constructs from the literature review are used. These constructs are the domain, discussed in the section by that name in Chapter II, and the metaphor theme, a term coined by Black (1979) and a concept used by Lakoff and Johnson (1980).

In this discussion, the metaphors used as examples are cited by the corpus author's initial and the page number where the example is found. B43, for example, indicates Burghardt corpus, page 43.

A related set of metaphors found in the corpora provides the following examples of a domain and a metaphor theme. The domain of theater encompasses the terms "play," "role," and "enter." Given this domain as source and taking life as a target domain results in the metaphor theme "life as theater." This metaphor theme is encoded in the corpora in examples like "engineers play a unique and fundamental role" (B43), "robotics will play an important role" (E196), and "at this point Isaac Newton entered" (B25).

The constructs domain and metaphor theme are used in this

section to organize and discuss many of the metaphors found in the corpora. An attempt is made to use examples from both corpora to explain each source and target domain and each metaphor theme. Words used metaphorically are organized according to source domains in appendix G.

DISCUSSION OF THE SYNTACTIC CATEGORIES

The Copula Form

It is important to note that the copula form of metaphor was the least prevalent syntactic category for metaphor. There were similar structures that were no less explicitly metaphors than the easily recognizable copula form, but only five instances of metaphor out of a total corpus of 40,000 words were of the form "A is B."

The similar forms suggest that science, at the introductory level at least, has its own preferences for introducing metaphoric terminology. The use of the word "called" to introduce a metaphor is found in both corpora: "adding impurities is called 'doping'" (B229) and "the perpendicular distance, called the moment arm" (E225). A slight variation is also found: "a set of all possible observations ... is referred to as the population" (E145).

In the example B229 above, the metaphor is further highlighted by the use of quotation marks. Quotation marks are another method introductory science has of structurally marking metaphors. The example, "the 'center' of a set of

data" (E145) demonstrates this structure. The quotation marks are a signal not to take the term literally. They are a way of indicating that the meaning of the word is to be stretched, as in this example, "the recording head ... actually 'flies' over the disk surface" (E190). In this example, the head is not really flying despite the use of "actually." Quotation marks call attention to the word as a challenge to interpretation, as in this example, "movable positive charges, or 'holes'" (B228).

These alternative structures for marking metaphors have implications for the psychology of understanding metaphor. The mental effort of interpretation may vary in correlation to the structural presentation of a metaphor. As noted in the literature review, psycholinguistic research on metaphor focuses in large part on the copula form. This form is, in fact, the least represented in the data under investigation.

This finding and the finding that introductory science may have its own preferred structures for introducing terms used metaphorically lead to the conclusion that the psycholinguistic approach to the investigation of metaphor must be expanded. Furthermore, these findings lead to the conclusion that the burden on the teacher is much more than the explication of metaphors in the form "A is B."

Metaphoric Use of Place Prepositions

The place preposition category accounted for more than 40% of the tokens in both corpora. Of particular importance

within this syntactic category are the place prepositions "in" and "on." These two place prepositions themselves can be categorized according to the way they are used metaphorically. This section concerns the categorization of these two prepositions and a discussion of the metaphoric use of other place prepositions.

The Preposition "In"

The preposition "in" has by far the highest types-to-tokens ratio in both corpora. This preposition is used metaphorically in a number of distinguishable ways in the corpora. Some of the uses occur only once or very rarely. These include "keep in mind" (E101), "cast in lead" (B36), and "in addition" (E145). Example E101 can be explained as the conception of the mind as a container. Example B36 is a bit more problematic; perhaps the material can be thought of as a field. Example E145, to date, defies a metaphoric interpretation. These examples are the minority. Most of the occurrences of the metaphoric use of "in" are part of a pattern.

The metaphoric use of the place preposition "in" can be divided into seven categories according to metaphor themes. These seven categories are "in a field," "in a process," "in a book," "in time," "in a state," "in a path," and a miscellaneous category. This break down of the use of "in" for the combined corpora is shown in Figure 9 on the following page.

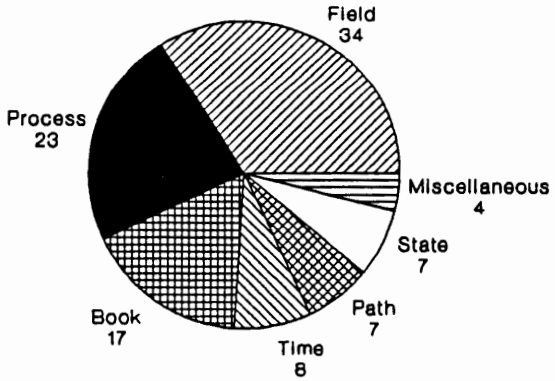

Figure 9. Metaphoric uses of the preposition "in."

In a field. The category "in a field" contains the greatest number of "in" tokens. This category is related to the section below "The Field as Source" (p.71). It includes the use of "in" when discussing a discipline: "advances in metallurgy" (B29). Also included in this category are the uses of "in" with a field conception of a quality, a measure, or a language.

The quality as field conception occurs in examples like, "in general" (B29), "in contradiction" (B36), "in fact" (E119), and "differences in IQ" (E162). Interestingly, in the first three examples above there is an implicit relationship of opposition. The fields of generality, contradiction, and fact contrast with the fields of specificity, accordance, and fantasy respectively. All members of these three anatomic sets take the place preposition "in."

Measures are conceptualized as fields if the use of "in" is taken as evidence. Examples of this conceptualization include "measured in days" (B23), "measured in pounds mass"

(B195), and "measured in Newtons" (E132). The measure, metaphorically, is the field of operation, the location of the action of measuring.

Language is conceptualized as a field in a similar way. The language is metaphorically the field of operation in examples like, "written in Fortran" (E184). The language need not be complete, as these examples show, "in other words" (E135) and "think in terms of the big picture" (E201).

In a process. The category "in a process" stems from the metaphoric conception of a process as a container. The prototype example of this category is "in a process" (E274). The use of "in" in conjunction with a gerund is a prevalent manifestation of "in a process." Examples include "used in forming utensils" (B25), "in designing the nozzle" (B68), and "skill in making and interpreting measurement" (E100). Similar examples include "a limitation in the conversion of heat" (E311) and "in the manufacture of its copiers" (B217).

In a book. The category "in a book" is based on the conception of a book or other written material as a container. Examples of this category include "in Novum Organum" (B25), "in research journals" (B124), "in sec. 7.5.1" (E195), and "in fig. 8.4" (E201).

In time. Time is metaphorically conceived of as a container, resulting in the category "in time." A year can be a container: "in 1620" (B25). Time in general can be a container: "the time they are in" (B43), "in the past" (119),

and "in the future" (B43).

In a state. Members of the category "in a state," based on the conception of a state as a container, are often realized by the phrase "... resulted in ...." Examples include "the creation of new materials has resulted in a variety of products" (B39) and "their use has resulted in rapid developments" (E173). Other examples of this metaphoric use of "in" include "in charge of work" (B53), "in spite of many attempts" (E119), and "in disarray" (B43).

In a path. The category "in a path" stems from the metaphoric conception of a path as a container. The clear example of this category, "in at least two ways" (B249), leads to the inclusion of similar examples like "in a haphazard fashion" (B195). Here, a conception of manner as path is assumed. The category includes uses such as "in that direction" (E119) as well.

The Preposition "On"

In both corpora the types-to-tokens ratio of the place preposition "on" was second only to that of "in." Unlike "in," however, "on" can only be broken down into two categories of metaphoric use. "On" can be used to set up a structure relationship, and it can be used as it is to talk about light falling on something.

"On" as structure. Structure as a source is discussed in more detail in its own section of this chapter (p.85). The place preposition "on" can create a structure relationship

metaphorically. It is often used with "depend," as in these examples, "not dependent on a civilized nature but on a civilized mind" (B35) and "depending on the specific application" (E121). These examples demonstrate the structure relationship; the mind or application is the foundation of something. Subject matter is the foundation for books and elaboration: "books on economics and society" (B43) and "to elaborate on this point" (E101). Documents are built on opinion: "a document that relies on the opinions of others" (B115). The use of "on" with a time period sets the time period up as a base for action: "on many occasions, designers have had to repeat some steps" (E370).

"On" as light. Certain phenomena are metaphorically akin to light, as evidenced by the use of "on" in conjunction with these phenomena. The corpora yield such examples as "the ramifications of technology on our lives" (B23), "emphasis on the hardware" (B63), and "effect on the value" (E145).

Miscellaneous "on." As with the place preposition "in," there is a miscellaneous category of the metaphoric uses of "on." This category includes such conceptualizations as "on a path" and the idea of being bound up. Examples of the former include "the list could go on and on" (B39) and "continues on into a later section" (E201). An example of the latter conceptualization is "this limitation on heat conversion" (E311), where the limitation is, metaphorically, a rope, binding heat conversion.

Other Place Prepositions

A number of other place prepositions were used metaphorically in the corpora. The types-to-tokens ratios for these other place prepositions did not approach the ratios for "in" and "on." Certain conceptions emerge from the analysis of these other place prepositions.

Time is conceived of as a line or path. This leads to the use of "at," as in this example, "at the same time" (E119). The conception of time as a line allows for time spans: "from the beginnings to the present day" (B23) and "the time from idea to marketable product" (E195). A life time is conceived of as a line as well, leading to the conception of important events as points on that line: "at retirement" (E351).

The line conception is important in organizing other domains. Processes are conceived of as lines in these examples, "the transition from the feudal society to the industrial one" (B25), "progress from a simple mold to a more complex mold" (B29), and "an orderly transition from many systems of units to one system" (E119). The products issued by a company are conceived of as a line: "from automotive tires to mechanical gears" (B39). Finally, disciplines are conceived of as a line: "from English to engineering" (B256).

Closely related to the line conception is the conduit conception discussed by Reddy (1979). The use of the place preposition "through" indicates a conduit conception of means.

Examples of this conception include "getting things done through others" (B77) and "made possible through the use of integrated data bases" (E196). Processes are also conceived of as conduits: "let's go through an example" (E274).

Light appears to be the source domain for the use of "under" in conjunction with certain phenomena. Light creates and defines the space it illuminates when it strikes a surface. This property of light leads to metaphors based on it. Examples of the metaphoric use of "under" include "even under the best of circumstances" (B80) and "the system under consideration" (B187). "Upon," the opposite of "under," is also used in the same way: "influence upon the results" (E121).

The metaphoric use of other place prepositions includes the completive use of "up," the completive use of "out," and the use of "on" and "off" for the closing and opening of an electric circuit.

The Adjectives as Antonymic Sets

Many of the adjectives used metaphorically in the corpora are members of antonymic sets. Evidence of the following antonymic sets are found in both corpora. The words in italics did not appear in either corpora:

{high, low}	{wide, *narrow*}	{near, far}
{hard, soft}	{rough, smooth}	{poor, *rich*}
{dark, *light*}	{clean, dirty}	{large, small}

{strong, weak} {fresh, *rotten*} {short, long}

{raw, *cooked*} {close, distant} {broad, *narrow*}

{global, *local*} {upper, lower}

{positive, neutral, negative}

The relationship of opposition common to these sets is preserved when the words of these sets are used in target domains. What follows of this section is a discussion of the use of some of the more prevalent antonymic sets.

High and low. One of the more prominent sets in both corpora is {high, low}. The set can be expanded to {highest, higher, high, low, lower, lowest}, a graded antonymic set. Metaphorically, this set is used to qualify creativity: "a time of heightened creativity" (B25); voice quality: "[our voices] are either too high or too low" (E414); quality: "equipment of high quality" (E100); proficiency: "the highest attainable proficiency" (E319); precision: "high precision" (B175); accuracy: "high accuracy" (B175); pressure: "even lower pressure" (E328); and, among others, temperature: "bronze has a lower melting point" (B29).

Temperature provides an interesting example of the arbitrariness of assigning a temperature scale a high-low orientation. Burghardt retells this anecdote, "Anders Celsius devised a scale that started at 100 (triple point) and went to 0 (boiling point). A friend suggested he reverse them, which resulted in the current Celsius temperature scale" (p. 193). This anecdote illustrates that it is the relationship of

opposition between high and low that is important to the description of temperature as opposed to the physical relationship high and low express. The use of {high, low} in this way is prevalent in measurements: "a very high rate of speed" (B219) and "high power output" (E325).

The {high, low} set, when used metaphorically to qualify non-physical relationships, tends to indicate that high is better and low is worse. This is the case when the set is used to qualify a given quality: "high-strength aluminum" (B207) and "highly desirable" (E372). This pattern is noted and documented in Lakoff and Johnson (1980). It is evident in examples like "one of the high-level languages" (E184), "downgrade some available energy" (E319), and even "from entry level to senior management" (B201).

Positive, neutral, and negative. This graded antonymic set of adjectives is used to describe the relationship between protons, neutrons, and electrons in the corpora. In addition, the set is used to make value judgements based on a conception of positive being good and negative being bad. Examples drawn from the corpora include "change viewed positively" (B31), "negative qualities" (B36), and "positive characteristics" (E131).

DISCUSSION BY DOMAINS

A domain conception of language facilitates the organization of seemingly disparate metaphors. The source and target domains of a metaphor can be identified, and this metaphor can then be compared to other metaphors in terms of source and target domains. For the second language classroom, frequently exploited source and target domains provide important vocabulary.

Process as Path

Metaphorically, a process is conceived of as a path, as demonstrated in this example, "a process, on the other hand, is a phenomenon identified through step-by-step changes that lead toward a required result" (E370). Example E370 is characteristic of the process as path metaphor; the terminology of paths, especially "step" is exploited to explain processes. In this section, the process as path metaphor theme is discussed with particular attention to the problem solving process presented as path.

In a discussion of the research process, Burghardt states, "At this juncture two paths are open" (B124). to understand this statement, the reader must be familiar with the process as path conception. The anaphoric reference to a metaphoric "juncture" must be linked to a prior non-metaphoric referent. Furthermore, the reference to "open paths" should signal to the reader that a description of two mutually

exclusive, institutionalized processes will follow.

Anaphoric reference is not uncommon in the use of the path domain to describe the process domain. There are a total of nine anaphoric uses of "step" in the two corpora combined. In these cases, the frequent use of step and the explicit definition of what a step is in a given process serve to diminish the cognitive load of tracing the anaphor back to its referent. A more complex situation arises with this example, "significant steps in that direction are presently underway" (E119). "That direction" in this example is "full conversion to the metric system" (E119). The process of conversion must be recognized as a path if "steps," "direction," and "underway" are to make sense for the reader.

The process of problem solving as discussed in both corpora provides an excellent example of the conceptualization of a process as a path. The full extent of what this conceptualization entails linguistically and cognitively is evident in the authors' discussions of the problem solving process.

To begin with, the process of problem solving is highlighted metaphorically as the goal of an education as path metaphor: "your education is directed towards solving problems" (B77).

Eide, et al. metaphorically place the problem solving process in the path domain by the use of "in terms of" in this example, "the engineering method of problem solving was

described in terms of the following six-step procedure" (E199). The metaphoric use of "step" in this example identifies the process as a path. Additionally, the word "procedure" stems from the latin "to go forward," although for the purpose of this paper the term is well enough established as appropriate to the process domain to prevent counting it as metaphoric. The path source is further exploited by Eide, et al. in their discussion in this example, "you must proceed through the several preliminary steps" (E199). It is in Burghardt's discussion of problem solving, however, that the path domain is most exploited.

At the start of his discussion, Burghardt refers to "guidelines in problem solution" (B124). The abstract process of problem solving is made less so by reference to physically knowable "guidelines" borrowed from the domain of construction. The location of these "guidelines *in* problem solution" is another hint that processes are considered paths, given that the path as container metaphor theme is so prevalent.

Burghardt continues his discussion, "problem solving is not easily learned just by following steps" (B124). Both the words "following" and "steps" are appropriated from the domain of paths. "Steps" is a straightforward metaphor in which the smallest discrete increment of progression along a path is, through catachresis, the smallest discrete increment of progression toward the goal of a process.

The problem solving process Burghardt describes is an institution of Western science. By metaphorically describing it as a path to follow, including the steps to take, Burghardt highlights the importance of replicating the process to students of science. The process, however, is not a path, leading to the issue of the warning, "not easily learned...."

Despite the warning, Burghardt proceeds to a more profound exploitation of the process as path metaphor theme. In the sentence following B124, Burghardt writes, "the ones [steps] mentioned above give us a direction to proceed in, but the path in that direction is not always clear" (B124). The process of problem solving is endowed with direction and explicitly equated with a path. As a path, the process is prone to the phenomena that affect paths, such as obstructions.

Discipline as Field

In both corpora, the discipline of engineering is conceptualized as a field. This conceptualization is most clear in this example, "the field of engineering" (B53), and others like it. Particular sub-disciplines of engineering are also conceptualized as fields, as in these examples: "all fields of engineering" (B205), and "a particular field of engineering" (E121). Activity in general is conceptualized as physical space: "seven general areas of activity for engineers" (B71). This conceptualization of disciplines and activities as physical space leads to the use of terminology

drawn from the field domain to describe disciplines and activities.

Metaphorically, activity, of almost any kind, takes place within a labeled container. This is reflected in the language used to talk about disciplines or categories of activity. The following example is illustrative: "not only in technology but in all areas of human activity" (B25). The use of the place preposition "in" with "technology" and the reference to other "*areas* of human activity" demonstrate the conceptualization of activity through metaphoric means. The use of "in" as in the example above is particularly widespread in both corpora and often serves to identify distinct disciplines. An example of this is "developments in transportation, health care, business management, education, and national defense" (E173).

Although the use of "in" is one of the most notable results of a field conception of disciplines, it is by no means the only one. Another result of this conception is that the physical properties of fields are used to describe disciplines. Disciplines are given boundaries as in this example, "[environmental engineering] crosses the boundaries of many disciplines" (B65). The attribution of boundaries to disciplines leads to the use of "overlap" as in this example, "education often overlaps in adjacent areas" (B49). In fact, the idea in this example that "areas" of engineering may be "adjacent" demonstrates another facet of a field conception of

discipline.

Consider the two adjacent areas pictured in Figure 10 below. Figure 10 stems from the following example: "advances in engineering parallel advances in society" (B53).

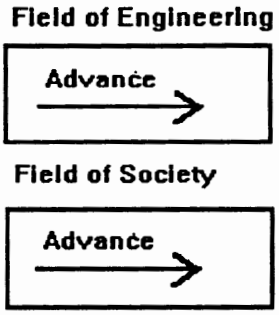

Figure 10. A field conception of "advances in engineering and society."

In this example, the two activities of engineering and society are conceptualized as fields. The activity taking place in these two fields is conceptualized as movement, as demonstrated by the use of "advances." This is symbolized in Figure 10 by arrows. Furthermore, the movement in the two fields is related by the use of "parallel," a term appropriate to the description of physical space.

In another example, "engineering is always pivotally involved in the creation of new technologies" (B23), one discipline is put into a physical relationship with many other disciplines. The conception of disciplines as fields allows for operations, such as boundary crossing and movement, and arrangements, such as adjacent and parallel, that would not be possible if disciplines were not conceptualized in terms of fields.

Movement in a field is an important conceptualization for the description of disciplines in both corpora. The use of "advances" occurs in both corpora, but it is particularly prevalent in the Burghardt corpus. Examples like "advances in metallurgy" (B29), "technological advances" (B35), and "advances in technology" (E173) stand as evidence. In one example, the agent advancing is given: "the world advanced in technology" (E119). In another example, what counts as an advancement is made explicit: "anesthesia was a significant advancement" (E173). The conceptualization of moving through a field combined with the conceptualization of bounded disciplines results in the movement of the boundaries, as in this example, "the leading edge of development in a given field" (B205).

There are other examples of movement that demonstrate the cohesiveness of the discipline as field metaphor. For example, the inventions of a particular discipline are, metaphorically, involved in a race through the field: "the forerunner of the slide rule" (E176). Sometimes they are prevented from running: "the major drawback of the analog computer" (E179). And sometimes they move right along: "magnetic disk technology has made giant strides" (E190) and "in pottery the Greeks made strides" (B29).

One final result of a discipline as field conception concerns those who practice the discipline. They are located and operate within the discipline. "Seek out" in the example

"the scientist's role is to seek out new understanding" (B49) indicates the scientist's operation within a metaphorically created space. Furthermore, practitioners "look out" from their discipline as in this example, "from a manufacturing standpoint" (E196).

The field is the primary source of terminology for the description of disciplines. Other field-like conceptions are possible, however, and they occur in the data. Some examples include "the engineering world" (B205) and "technologies in the industrial arena" (B77). Furthermore, alternative non-field conceptions are not unknown. Kuhn (1970) devotes an entire book to de-metaphorizing the disciplines of science, in large part, by attacking the metaphor of movement through a field. Nevertheless, the field metaphor for disciplines remains prominent in the two introductory texts examined in this study.

Other Uses of Field as a Source Domain

Although the use of the source domain of fields is most prevalent with respect to disciplines and activities, it is used to describe other target domains. Lakoff and Johnson (1980) note the use of the field domain to describe the domain of sight, and this metaphor is evident in the corpora: "put the matter into perspective" (E179). In addition to this use of the field domain, others occur in the corpora under investigation. The domain of qualities, broadly speaking, is also conceptualized as a field.

This conceptualization of the domain of qualities is most obvious in this example: "an area of confusion" (B189). There are, as well, a substantial number of set lexical phrases regarding quality that demonstrate a field conception of the domain. These include "in general" (E173, B175), "in all probability" (E100), "in nature" (E176), "in fact" (E119), "in actuality" (E121), and "in common" (E99). The field conception of the latter example, E99, is further demonstrated in this example: "the area of commonality" (B63).

More specific qualities are also conceived of as fields, as in this example, "in quantity, temperature, salinity, and mineral content" (E328). An understanding of this field conception of qualities leads to the following analysis of this example: "the differences in speed between the I/O device and the CPU" (E184). Figure 11 below shows the two fields of the I/O device and the CPU. In between and shared by these two fields is the field of speed. Within the field of speed, the circles represent the differences in speed.

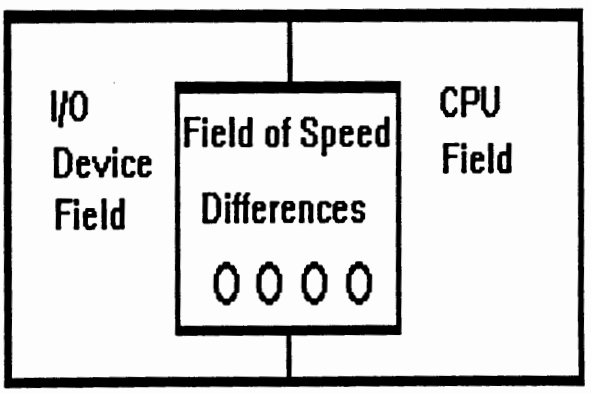

Figure 11. A field conception of "differences in speed."

The Body and the Life Cycle

The body and the life cycle are two more important source domains. From its use to describe the two sides of a coin to its use to categorize equations, the body domain is evident as a conceptual starting point and organizer. The resemblance of one side of a coin to a head leads to the use of "tail" for the other side based on the spatial relationship of the head to the tail on bodies. The structural significance and incompleteness of a skeleton leads to "a skeleton equation" (E259), an equation that contains all the chemical elements but that is as yet incomplete.

The term "body" itself is used as a cover term for any physical object - "ore bodies" (B69), "the force acting on a body" (B195), and "body Q" (E219). Indeed, physics may seem macabre if the metaphor is not recognized, as this example illustrates, "the velocity a body achieves when falling" (B36). "Body," though, can be used as a part of a whole as well, as in this example, "the main body of a report" (B115).

The use of terms from the body domain display the division of uses implicit in the discussion of "body" above. The terms are used in isolation of the actual body organization or they exploit this organization. Examples of the former category include "toothed wheels" (E176), "the second hand on a clock" (E176), and "the moment arm" (E225). The use of body domain terms in these examples is descriptive but not relational; there is no suggestion of a "mouth" of

the wheel or the "torso" of a clock or of a moment.

In the latter category, metaphoric usage that takes advantage of body domain relationships, such examples as "the heart of the computer" (B249) and "the lifeblood of our industrial society" (B71) are found. The "heart" in the first example stands in contrast to the "body," or the less important parts, of the computer. In the second example, the use of "lifeblood" sets up an implicit metaphor of the petroleum engineer as the "heart" of the industrial society "involved with sustaining its [petroleum's] flow" (B71). In both these examples, the relationships that obtain in the source domain obtain in the target domain. In another example, "the specimens will begin to neck down sharply" (E236), the relationship of the neck as thin part between the head and torso is exploited.

Finally, metaphors based on the body domain as source domain can be combined with metaphors based on other source domains. For example, the combination of development as a path and countries as bodies, or people, on that path results in the following example: "foreign competition has several years' head start" (B77).

Closely related to the body domain is the life domain. Example B71, "the lifeblood of our industrial society," mentioned above, neatly demonstrates the interdependence of bodies and life. The interpretation of countries as bodies in example B77 in the previous paragraph is borne out in the

following example in which a country is, metaphorically, given life: "the USSR experienced its birth" (B43).

Like countries, disciplines and companies can be conceived of as alive, as in these examples, "it [environmental engineering] is developing a separate identity" (B65) and "for a company to survive" (E372). In the corpora under investigation here, however, it is manufactured items which are most often discussed as living.

The life cycle is a convenient framework for discussing the histories of manufactured products. As Eide, et al. put it, "most of the products have a life cycle that goes from the development stage ... to the point where the product becomes obsolete" (p. 372). At another point, life is defined as "the number of years of service" (E352). Products have life expectancies as well: "the wing's life expectancy" (B55). Materials are subject to the constraints imposed by life and they "fatigue after too much flexing" (B55). The use of life as a source domain enables the description of the development through time of inanimate objects.

Ideas and Images from Below

Ideas and images in both corpora are conceived metaphorically as rising up or emerging. Examples of this pattern include "the image conjured up may be a green frog" (B59), "censor ideas before allowing them to surface" (B206), and "several advantages spring to mind" (B263). Concepts can be drawn out of a metaphorically conceived depth: "we can

draw two important points from this discussion" (E121).

Furthermore, an idea or concept is conceived of as having depth: "we cannot hope to delve into all the complexities of statistics" (B162) and "exploring a perfectly good idea in more depth" (E411).

Finally, the conception of the mind as having depth leads to the converse of ideas arising, as in this example, "the word 'invention' strikes fear into the minds of many people" (E121). This metaphoric conception is apparent in the mind as container metaphor: "keeping in mind" (B138) and "keep in mind" (E195).

The Domain of Nature

Nature proves to be an important source domain for the description of diverse target domains. One of the most cited metaphoric conceptions, the hydraulic model of electricity, is, in fact, drawn from the domain of nature. According to this conception, which is present in both corpora, the observable phenomena of flowing water and the terms to describe it are used to explain electricity. In this classic case of catachresis terms such as "current," "flow," and "drift" have been borrowed from the domain of water to describe the movement of electrons. This is, however, neither the only use of the water domain as source nor the only source domain used to describe electricity.

Water is the source domain for a description of a common problem solving method: "a flowchart is a graphical

representation of an algorithm" (E201). The flow has direction - "the flow direction" (E201) - and it has a source - "the flow begins at the start position" (E201). Like a river, the flowchart branches: "each branch of the decision" (E201). Burghardt, in contrast, discusses "a decision tree" (B201). Although "branch" does not occur in the Burghardt corpus in this context, it is safe to assume "branches" are an important conceptual element of the decision "tree."

This discussion leads to the recognition of the ambiguity of the term "branch" mentioned in the literature review. Burghardt's characterization of "the nature of engineering, ever growing" (B68) supports a tree branch interpretation of "engineering was divided into two branches" (B36). On the other hand, a river branch interpretation of "the many branches of engineering" (E99) is supported by the statement that "engineering has spawned a myriad of specialties" (E99). The confusion is complete given "a source of error can stem from a difference" (E100).

Regardless of the confusion, the terms of the water domain and the plant domain are often used to describe other domains. For example, with respect to the water domain, Eide et al. discuss "cash flow" (E351), "a source program" (E184), and that "we can draw two important points from this discussion" (E121), while Burghardt discusses "watershed events" (B23), "information overflow" (B65), "problems running over to another sheet" (B187), and the fact that "we are

immersed in computer technology" (B39).

With respect to the plant domain, many things are characterized as growing: "as the technology grows" (E173) and "the computer industry is growing" (E173). Conceptually, it is a small step from the idea that things are growing to the idea of harvesting what has grown. Examples of the latter concept include "harvesting minerals" (B68), "computation can yield substantial results" (E173), "each [method] yields the same conclusion" (E352), and, less obviously, "the forces had been gathering strength" (B25). Things do not have to be harvested, however, only to mature: "for the industrial age to blossom" (B35).

Other examples of nature as a source domain include the conception of a word as a plant - "the root of the word engineer" (B35); demand as a mountain chain - "the peak demand period" (E372); and the conception of energy as a beast - "the energy ... is difficult to capture" (E325) and "horsepower-hour" (B131). On a larger scale, the whole of nature is taken as source domain. Examples include "activism was a part of the landscape in every nation" (B43), "political, economic, and social environment" (B43), "the panorama of opportunities" (B71), and "technical background" (B71).

Finally, the description of the domain of electricity does not depend exclusively on the water domain for its delineation. The orbiting of planets describes "electrons orbiting the nucleus" (E286). This description is inadequate,

however, and other metaphors are used: "the surrounding electron cloud" (E286) and electron "shells" (E286). Apart from the atom, the movement of free electrons is described as the behavior of birds: "electrons migrate" (B229). The conceptualization of electricity through observable phenomena occurring in nature demonstrates the metaphoric use of the concrete to describe the abstract.

Sight as Knowledge

In both corpora, the sense of sight is used metaphorically to indicate knowledge or study. This metaphor theme is most prevalent in the lexical phrase "in light of" and its variations. Examples of this phrase include "best value in light of a criterion" (E403), "in light of evolving technology" (B49), and "show them [analytic abilities] in the best light" (B113). In these examples, something is made visible metaphorically and it is thereby known. This section concerns this and other manifestations of the seeing as knowing metaphor theme.

People operate from a perspective. Metaphorically, these people have a view of something. Examples in the corpora include "the way society views the world" (B25), "the Greek view of the world" (B31), and "views on resource recovery" (E414).

The conception of knowledge or opinion as a view mixes well with the conception of disciplines as fields. This leads to the explication of the views of those who are luminaries in

their field: "the view of Aristotle" (B36) and "[Veblen's] views on engineering" (B43). Furthermore, people metaphorically located in the field acquire a viewpoint: "the engineer looks at design from two viewpoints" (B68) and "the software viewpoint" (B63).

The metaphorical location of people in fields is akin to the metaphorical location of people above things, looking down on them. This conception occurs in the Burghardt corpus as "an overview of the report" (B115) and "the encyclopedia has an overview of the particular subject by an authority in the field" (B124). This latter example, B124, includes the field conception of discipline, producing an image, on literal interpretation, of an authority looking down on a field he or she knows well and describing the view.

The idea of perspective itself is exploited as in this example, "put the matter into perspective" (E179). Similar in conception to this example is the use of focus to indicate study. An example within the seeing as knowing metaphor theme is "before focusing on the details" (E201), but outside this theme "you can focus your efforts" (B191). Less intense than focus is a look: "before we look at some procedures" (E131), "let's look at some basic definitions" (E132), and "let's see how it is used" (B162). In the same vein, a text is conceived of as presenting a perspective of its own: "beyond the scope of this text" (B205, E319).

The somewhat idiomatic "big picture" (E201) mentioned by

Eide, et al. underscores another manifestation of the seeing as knowing metaphor theme. Things, metaphorically, draw pictures of other things: "they [sources of error] illustrate an important problem" (E100) and "to illustrate optimization" (E403). The future, too, seems to be some kind of picture in this example, "a glance at the future" (E176).

Other manifestations of the seeing as knowing metaphor found in the corpora include the attribution of an eye to the public, the idea of clarity, and a signaling mechanism. The public knows or opines by sight in this example, "environmental assessment is important in the public eye" (B65), which borrows the word "eye" from the domain of sight. Although one might argue that a "clear view" is based on a path of sight metaphor, clarity is here taken to come from the domain of sight. This judgement, made on the basis of examples such as "to more clearly visualize the definition of a system" (E271) and others not in the corpora such as "crystal clear," leads to the incorporation of metaphors like "step 4, however, often lacks clarity" (B189) into the seeing as knowing metaphor theme. Finally, "notables have pointed out that the U.S. has no peer" (B77) depends on a literal interpretation of pointing out as a function of sight.

Structure as a Source Domain

The domain of structure, human made buildings, is exploited to describe a number of distinct target domains. Lines and diagrams, for example, are "constructed" (B138,

E274), and the metaphor is obvious in "synthesizing (building up)" (E286). At the most explicit level, "society is structured" (B23) and "mathematics is the structure" (B25). Eide, et al. describe "the fundamental decision structure" (E201) and proceeds, metaphorically, to build on this structure: "based on the outcome of a decision" (E201). This conception of something as a base to build on is frequent in both corpora and makes up the bulk of this discussion.

Continuing the "society is structured" (B23) metaphor mentioned above, the foundation of modern social structure is given, "agrarian societies formed the basis of civilization" (B23). Given agrarian societies, "the agrarian structure" (B36) follows. Rising up in contrast to this structure is "an industrial based structure" (B36). Societies, however, are not the only structures.

Systems occur as structures as well. Systems of measurement, such as time and temperature, are built up from base units: "the second is the base unit" (E131) and "fundamental or base units" (B197). These units, in turn, are based on observable phenomena: "the basis of our day-to-day observation of time" (B197) and "temperature scales are for the most part based on two points" (B193).

Disciplines, theories, and laws also occur, metaphorically, as structures. Eide et al. discusses "the foundation of statistics" (E142), and Burghardt includes "statistical methods, based on the works of Genichi Toguchi"

(B217). Examples of theories and laws as structures include "the theory provides the basis for practical engines" (E319) and "the basis of the second law" (E311). In the following example, the process of building up is evident: "the laws of mechanics gave rise to our increased understanding of the world" (B25).

In addition to the terms "base" and "basis," the terms "underlie" and "support" are often used metaphorically to create a structure. In an odd turn of phrase Burghardt notes, "the underlying effects are usually fundamental" (B23). Another similar example is "this statistic underlies the importance of knowledge" (E337). The converse of "based on" or "underlies" is "supported by," which is used in these examples, "engineering design and effort is supported by government funding" (B36), "write reports in support of getting things done" (B77), and "mainframes can support time sharing terminals" (E190). In the latter example, "mainframe" itself is a structure metaphor.

The relationship of dependence between the foundation of a structure and what is built on it holds when the terminology of the structure source domain is used metaphorically to explain a target domain. In this example, "communication with a computer depends upon the hardware" (E184), the shape of the foundation dictates the shape of the rest of the structure. Likewise, "on the basis of this information" (E142) sets up a relationship in which the information determines future

action. The use of terms such as "foundation," "base," and "support" in domains other than the structure domains signals a structure relationship between ideas and concepts.

CHAPTER V

CONCLUSIONS

Teacher awareness is the critical factor in exploiting metaphoric conceptions in the classroom. Metaphors are prevalent in even the introductory engineering textbooks under consideration here. Metaphoric concepts do structure a substantial amount of language, but teachers must decide if this is the best organization for vocabulary instruction in their classrooms.

To borrow a chapter from engineering, various factors must be weighted by the teacher before a competent decision regarding the use of metaphor in the classroom can be made. Examining and discussing interesting metaphors drawn from literature is a distinctly different exercise than exploiting a structure source to build an argument. Questions about when to teach metaphor, what to teach about it, and how to teach it can only be answered by a teacher confronted with the needs of a particular group of students.

In this final chapter, the results of this study are discussed. The metaphor themes and the important source domains found in the corpora are reiterated. Some suggestions are offered as to how these themes and sources might be used in the English language classroom. Then, the lack of

pedagogic metaphors found in the corpora is discussed and the implications of this finding are examined. Finally, I note the limitations of this study and offer some suggestions for further study.

The Results of this Study

Two introductory engineering textbooks were examined for occurrences of metaphor. A density of metaphor of 4.66% was found for the 40,000 word total corpus. The 20,000 word Eide corpus yielded a density of metaphor of 4.56%, and the Burghardt corpus yielded a density of metaphor of 4.76%. The metaphor densities found in the corpora far exceed the metaphor densities of roughly 1% found by Salager-Meyer (1990) in the only comparable study of metaphor.

When the words used metaphorically were examined by type, the results showed over 50% of the words were used only once. In the Eide corpus, words were used only once 57% of the time, and in the Burghardt corpus, words were used only once 60% of the time. Despite this finding, many of the words used only once were part of a larger metaphor theme that encompassed other words used metaphorically in the corpora.

Division of the words used metaphorically in the corpora into syntactic categories led to several interesting findings. Foremost, nouns used metaphorically in a copula were almost non-existent. Second, when the category of place prepositions was examined as tokens, it made up over 40% of the metaphor tokens in both corpora. As types, however, the place

preposition category accounted for under 10% of the metaphor types in both corpora. Third, the percentage of tokens of the verb and adjective categories in both corpora was much lower than the percentage of types of these two categories. In other words, specific verbs and adjectives often occurred only once as metaphors.

The density of metaphor and the syntactic category divisions were nearly the same in both corpora. The major difference between the corpora was the types of words used metaphorically. Forty percent of the types in the Eide corpus were also found in the Burghardt corpus. Conversely, 35% of the types found in the Burghardt corpus occurred in the Eide corpus.

Themes and Domains

Perhaps the most important finding of this study is the existence of metaphor themes in the introductory textbooks. The term "metaphor theme" was coined by Black (1979) to describe "an abstraction from the metaphorical statements in which it does or might occur" (p.25). Nattinger (1988) suggested such themes might organize substantial amounts of vocabulary. The metaphor themes found in the corpora investigated in this study present a structure for the metaphors found and, ultimately, a structure for organizing vocabulary.

Major metaphor themes found in the corpora are based on examples drawn from disparate parts of either corpus. Despite

the distribution of the examples, they can be grouped together under the appropriate metaphor theme. The "process as path" theme, for example, organizes such examples as "at this juncture two paths are open" (B124) and "significant steps in that direction are underway" (E119) as well as a large number of other examples.

The "discipline as field" conception is prevalent throughout both corpora. This theme undoubtedly recurs in many academic discourses. The "sight as knowledge" metaphor theme is apparent in casual discourse when we nod our heads and say, "I see," in agreement. Specific to engineering and science, the "electricity as water" metaphor theme has great explanatory value, but being a metaphor, it is a pitfall if taken too literally.

The metaphor theme, however, is not as powerful an organizer of vocabulary as the domain. The metaphor theme is limited to one set of metaphors based on the interaction of two specific domains. Examination of the metaphors in the corpora reveals that some domains serve as the source for more than one target domain. The language of the domain of paths, for example, is used to describe target domains other than the domain of processes.

In addition to the path domain, several other source domains stand out. The domain of containers, in particular the place preposition "in" from this domain, is used metaphorically to develop a number of target domains, from the

domain of time to the domain of disciplines. Nature is an important source domain for the target domains of decisions, disciplines, atoms, and energy. The body domain and the closely related life-cycle are also important source domains.

The words of these standout source domains can be assembled, as they are in appendix G. These words can be taught literally through demonstrations, pictures, and realia. When students seem to have grasped the literal meanings of the selected words, these words can be re-introduced as metaphors. The teacher can explain the metaphors or challenge the students to figure out the metaphors.

The teacher must be aware of the level of difficulty involved in figuring out a metaphor. Some metaphors are probably best used as explanatory devices for precocious or advanced students or used as teacher-training exercises. For example, the container metaphor encoded in the place preposition "in" can be quite abstract. The IN + gerund construction so prevalent in the corpora might be explained to students with reference to the "process as container" metaphor theme. A group of sentences with "in" and a challenge to categorize them by metaphor themes might be presented to a group of teachers-in-training to raise their awareness of metaphor as an explanatory and organizational tool.

Pedagogic Metaphor in the Corpora

As noted in the literature review, metaphor in science can be divided into three categories: conventional, theory

constitutive, and pedagogic. Conventional metaphors abound in the corpora. All the place preposition metaphors fall in this category as well as most of the other metaphors found in the corpora. Theory constitutive metaphors occur as well. The hydraulic model of electricity, "shells" and "orbits" of molecules, and positive "holes" all fall in the theory constitutive metaphor category. In contrast, there are almost no pedagogic metaphors in the corpora.

Because the corpora are drawn from introductory textbooks, it seems reasonable to expect more pedagogic metaphors than occurred, perhaps more of this category than of theory constitutive metaphors. Yet only one metaphor in both corpora is used for "leaping the epistemological chasm between old knowledge and radically new knowledge" (Petrie, 1979: P.440).

The one pedagogical metaphor is found in the Eide corpus. It is "the human brain, the "most packed" computer known" (p.191). The human brain is equated with a computer to demonstrate the limitations of computers.

This pedagogical metaphor can be contrasted with a theory constitutive metaphor to highlight the differences in the usage of these two types of metaphor. Succinctly, the pedagogical metaphor is used to explain and the theory constitutive metaphors are explained. For example, in a discussion of energy policy in the Burghardt corpus (p.228), the theory constitutive terms "hard" and "soft" are introduced

to describe fundamentally different energy policies. These terms are defined. In the "human brain as computer" metaphor above, the human brain is a definition of a computer.

Pedagogical metaphors may be a more immediate teaching tool that textbook writers avoid. A writer can safely assume that the readers will have brains and, in their own ways, understand brains, but too many assumptions will limit the audience. Furthermore, a textbook writer cannot anticipate all the comprehension problems all the students will have. Instead of cluttering the textbook with explanatory metaphors, the textbook writer will try to present the subject matter as literally as possible and leave the job of explaining the subject matter metaphorically to the classroom instructor.

Classroom instructors are in a position to observe the "epistemological chasm" and bridge it for their students. Being in direct contact with students, they will recognize comprehension problems. Additionally, through what shared experience they have with their students, classroom instructors will be able to provide an apt pedagogical metaphor and explain it or provide another.

Limitations of the Study

The most striking limitation of this study manifests itself in the low interrater agreement score. As noted above, this low score resulted from a difference in domain conceptions between the primary rater and the secondary rater. The primary rater was careful to ensure against over-training

the secondary rater. This suggests that more training may have been necessary.

This study is limited by the constructs used to identify metaphors in the corpora. The domain construct has not be fully developed, as noted in the literature review. There are no rules as of yet for identifying domains and ascertaining the delimitations of those domains. This study resorted to Richards' (1976) conception of the competent native speaker. This idealized speaker knows the limitations of the use of a word, the different meanings associated with the word, and the associations between that word and other words.

The competent native speaker construct failed in this study. Although two nominally competent native speakers rated the same text, they came to different conclusions in some cases based on different understandings of the use of words, the meanings associated with those words, and the associations between those words and others.

To give an example, the primary rater perceived use of the word "work" to be metaphoric in uses like "the conversion of heat into work" (E319). This perception stemmed from a conception of "work" as appropriate to the domain of human endeavor. The secondary rater did not share this conception of the word "work" and cited examples like "a machine works" to defend her choice.

An ideal speaker would, of course, have perfectly delimited domain conceptions. Domains, however, may be

different for different actual speakers based on the cultural background and experience of those speakers. If, for example, males and females in a particular culture develop distinct domain conceptions based on their genders, then this would explain the low interrater agreement score found in this study. So little is known about the psycholinguistics of domain conceptions, however, that any such explanation of the interrater agreement score found here is premature.

As D. Bergmann (1991) notes, "the first-order [source domain] meaning will vary according to individual knowledge and experience" (p.68). The primary rater brought his knowledge of and experience teaching English to bear in this study. This led to a careful consideration of the order in which NNSs might be exposed to English during the data collection process. The secondary rater did not consider NNSs when marking metaphors.

The secondary rater also noted comprehension problems related to the subject matter of the textbooks under consideration. At times, the secondary rate encountered problems with the terminology and explanations of engineering. This led to a literal interpretation of some words the primary rater considered metaphoric. Examples include "fatigue resistance" (B68), and "mainframe" (B256).

Finally, the large number of the metaphors involved precluded a discussion of every metaphor. The study, therefore, focused on sets of metaphors that could be

organized according to domains and metaphor themes. This means that many more isolated metaphors were not discussed.

Given the interrater reliability problems noted above, the inability to discuss every metaphor found in the text will limit the usefulness of the list of metaphor occurrences in Appendices E and F. The comparison of this study with other studies of metaphor in texts becomes problematic if the domain conceptions that led to a metaphor interpretation of a particular word is not known.

Suggestions for Pedagogy

As noted in the introduction of this study, it is a step suggested by D. Bergmann (1991) and Lindstromberg (1991). These two scholars examined the possibility of including the study of metaphor in English as a second language classrooms. They concluded that the next step in the process would be to select and organize vocabulary suited to metaphoric presentation. This study found just such a set of vocabulary.

Foremost, however, this study raises questions about the presentation of metaphor in the classroom. Overwhelmingly, the literature on metaphor focuses on the copula form of metaphor: A is B. The results of this study indicate that this is the least likely syntactic manifestation of metaphor to appear in introductory engineering textbooks. Classroom presentations of the use of metaphors in language must reflect the possible syntactic variations in the use of metaphors. This is easily accomplished by using metaphors found in

authentic texts.

Furthermore, while teachers must be aware that the copula form of metaphor is not necessarily the most prevalent, they must also be aware of other ways in which metaphor is marked. This study found a number of examples in which metaphors were marked with quotation marks or other signals such as the word "called." These methods of marking metaphoric use of language appear to be important to the introduction of technical language in the textbooks under study. Yet these marking methods are not mentioned in the literature on metaphor. The classroom teacher cannot ignore them.

The source domains isolated in this study and given in Appendix G provide a framework for vocabulary that should be taught with its metaphoric uses in mind. This vocabulary can be presented literally, through realia, examples, and experience. Entire source domains can be presented at once; for example, the teacher might present a section on nature and thereby supply the terms of the nature domain. Metaphoric uses can then be introduced coherently and consciously once the students have understood the literal meanings of the words.

This process of abstraction from literal meaning or actual experience to metaphoric meaning is central to Lakoff and Johnson's (1980) work on metaphor. An example of how it might work in the second language classroom follows.

In the American academic culture, arguments (term papers

or reports) are structures. A section on academic writing can begin with an examination of an actual structure. The school building provides a ready example. The students can be shown that the school has a "base" and "foundations." They can discuss how these elements influence further developments in the structure. Other terms from the structure domain such as "balance," "build," "construct," "level," "stress," "support," and "underlie" can be introduced. These terms, once understood literally, can be used metaphorically to discuss academic arguments. Ultimately, the terms can supply the framework for an academic paper in which the student consciously uses the terms in order to study the form of American academic writing.

The process of thinking metaphorically is, of course, an important skill for all students and teachers. The focus here is on students of a second language. They need the skill to make sense of a new language and the new metaphors of another culture. All students, however, should be taught to think metaphorically. This can be done by examining and exploiting metaphor themes such as "argument as structure" or any of the other themes identified in this study.

Thinking metaphorically is a prerequisite to teaching others to think metaphorically and interpret metaphors. Teachers must be made aware of the subtleties of language by those who train them. The ability to think metaphorically allows the teacher to isolate a metaphor theme such as "seeing

as knowing" and present that theme to students in a cohesive, easily accessible way.

Teacher trainers should stress metaphor in their classrooms and provide student teachers with exercises that encourage metaphoric thinking. Such exercises will follow the path highlighted by Lakoff and Johnson (1980) from experience to abstraction. One such exercise begins with something in a container. The use of the preposition "in" is clear in this first case. Student teachers can be challenged to categorize a set of sentences that demonstrate "in a book," "in time," "in a process," "in a path," "in a state," and "in a field." After these sentences have been categorized, the categories can be discussed and analyzed.

The hundreds of words in Appendix G are an important addition to the endeavor of teaching vocabulary. These words, which have been selected on the basis of their metaphoric use, should be examined by teachers. They should be weighed against other word lists according to the interests and abilities of the teacher and students. If found to be important, then, by all means, they should be used.

Suggestions for Further Research

Certainly the first suggestion for further research must be for psycholinguistic validation of the domain construct. Investigation must be conducted beyond the level of simple domains like the category of birds. A domain organization of the mental lexicon assumes a type of network connecting and

relating words. How closely associated are similar domains? It is possible that domains themselves may be connected or that they may even overlap. Domains, domain delimitations, and semantic fields all need further research.

Closely related to this first suggestion is the suggestion that the mental lexicon of the NNS be further investigated. The conclusions about the domain delimitations of the native speaker may not hold for a non-native speaker. Questions about the NNS's mental lexicon and the development of this lexicon must be addressed before the results of studies like this one can be applied in the classroom with confidence.

This study is only a small step in the process of using metaphor in the language classroom. A specific set of texts, appropriate to only a small audience, was investigated. Other texts must be investigated. The lack of pedagogical metaphors in the corpora lead to the suggestion that lectures and classroom interactions be investigated for occurrences of metaphor.

In addition, very little is known about the problems NNSs have interpreting metaphors. They may be able to guess the meaning of metaphors based on experience that they already have or they may not. They may encounter difficulties producing some of the conventional metaphors found in the corpora. Trouble producing prepositions used as metaphors, for example, might keep NNSs from writing adequate academic

papers.

In fact, very little is actually known about native speakers' ability to interpret and produce metaphor. Some work has been conducted concerning the interpretability of copula metaphors as opposed to literal language, but other syntactic manifestations of metaphor have largely been ignored. The results of this study show that the copula form is the least likely to be used in introductory engineering textbooks.

Comprehension and identification tests must be conducted for both native and non-native speakers of English and other languages. It is imperative that authentic texts be used in these comprehension and identification tests to ensure that the natural syntactic distribution of metaphor is reflected in the tests.

Finally, although I have made some suggestions concerning the use of metaphor in the classroom, the techniques I have mentioned are not the only ones possible and they have not been tested. Again the prepositions present an example. A test could be conducted to determine if a metaphoric approach to the teaching of place prepositions is more successful than a more conventional approach. The test could include interpretability and production.

Conclusions

Although this small step in the process of developing a working understanding of metaphor is not without its problems,

it is an important step. It is one of the few studies that examines a large portion of authentic language drawn from the introductory textbooks of a single discipline.

This study found that those textbooks were indeed saturated with instances of the use of metaphors. This finding suggests that more work must be done with other engineering texts and with the texts of other disciplines. The findings of the study suggest as well that more work must be done on refining the constructs used to define and identify metaphors.

The prevalence of metaphor in the textbooks examined in this study demands the attention of language teachers and linguists. Metaphor is indeed an important aspect of language and it should not be slighted with superficial definitions and testing limited to the copula form. Furthermore, on a more qualitative level, metaphor appears to be an important mode of thought for scientists and other creative people. It will benefit all if students learn to think in a metaphoric mode from their teachers.

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APPENDIX A

A SAMPLE OF THE EIDE CORPUS

your education, you may have been exposed to the conservation principles: the conservation of mass, of energy, of momentum, and of charge. From chemistry you are familiar with the laws of Charles, Boyle, and Guy-Lussac. In mechanics of materials, Hooke's law is a statement of the relationship between load and deformation. Newton's three principles serve as the basis of analysis of forces and the resulting motion and reactions.

Many methods exist to test the validity of an idea against the laws of nature. We might test the validity of an idea by constructing a mathematical model, for example. A good model will allow us to vary one parameter many times and examine the behavior of the other parameters. We may very well determine the limits within which we can work. Other times we will find that our boundary conditions have been violated and, therefore, the idea must be discarded.

Results of an analysis of a mathematical model are frequently presented as graphs. Very often the slopes of tangents to curves, points of intersection of curves, areas under or over or between curves, or other characteristics provide us with data that can be used directly in our designs.

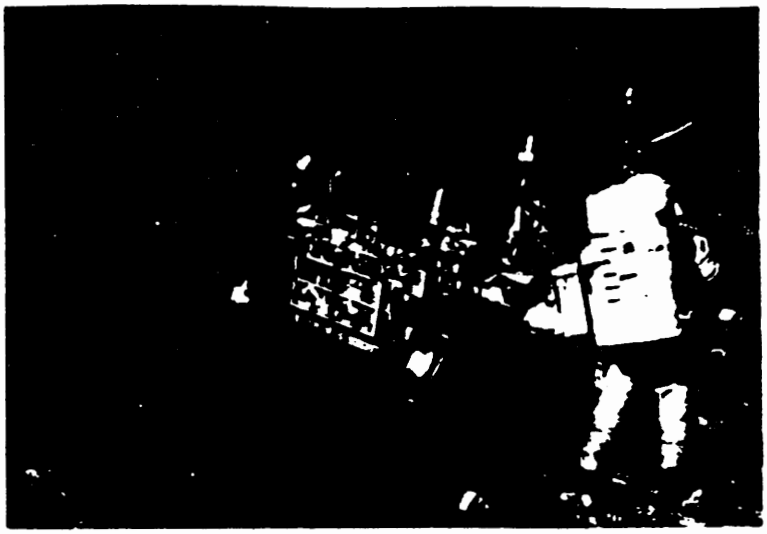
Computer graphics enables a mathematical model to be displayed on a screen. As parameters are varied, the changes in the model and its performance can also be quickly displayed to the engineer.

The preparation of scale models of proposed designs is often a necessary step (see Fig. 15.17). This can be a simple cardboard cutout or it can involve the expenditure of great sums of money to test the model under simulated conditions that will predict how the real thing will perform under actual use. A prototype or pilot plant is sometimes justified because the cost of a failure is too great to

Figure 15.16
Computer graphics enables complex designs to be modeled, verified, and analyzed without the expense of constructing a scale model or prototype (*International Business Machines Corporation*.)

APPENDIX B

A SAMPLE OF THE BURGHARDT CORPUS



Problem definition was no easy task when considering landing an astronaut on the moon's surface. A variety of factors, some of which could only be guessed at, had to be considered before solutions were created. (Courtesy of NASA)

assumed is often perplexing. On large projects there can be underlying questions concerning time constraints on implementation; some solutions won't work because they are too time intensive. When dealing with a subsystem or a component within a total system, defining the boundaries is of critical importance. There are compatibility problems to consider; specifications must state the input and output requirements of the unit. These become the criteria by which the design is judged in later steps.

Consider that you are called upon to design the coal loading system for railroad cars. One underlying constraint affecting the design could be that the train must keep moving at a certain velocity during the loading process. Problems have constraints on them, parameters within which solutions must function.

Creating Solutions

The next phase of the design process is creating solutions for the problem. Notice that solutions, the plural, is used; there will be several ways to resolve the problem, some better than others, but they all should be examined initially. Do not prejudge or censor ideas before allowing them to surface. This is where your technical education and engineering experience combines with your innate creative ability to develop problem solutions. The ways that have been used in the past may be just fine for the present situation: no new technology or manufacturing methods are needed. However, inventiveness is required when research and development have created new technologies that can be used for

APPENDIX C

INTERRATER RELIABILITY GUIDELINES

Interrater Reliability Guidelines

This is a study of metaphors in two introductory engineering textbooks. In this study, metaphor is defined according to a domain interaction approach. A domain is a set of related words. For example, the domain of swimming includes such terms as "pool," "deep," "backstroke," etc. Metaphor occurs when a term is borrowed from one domain to explain another domain. In the metaphor "drowning in paperwork," a term from the domain of swimming is borrowed to explain the domain of clerical work.

Metaphors are often literally false - no one drowns in paperwork. This is an important test for metaphors. Sometimes literal falseness is subtle, as in this example, "a rich cream sauce." It is up to you to decide if a word from one domain is borrowed to describe another domain according to your own knowledge of domain delimitations as an English speaker.

Each word in the corpus must be carefully scrutinized. Metaphors are not limited to one grammatical realization. They can be nouns: the third step in a process; adjectives: the dark ages; verbs: drown in paperwork; adverbs: speak softly; and prepositions: in engineering, that depends on the information, under the influence, etc. The preposition class presents a problematic case. Because they are not generally considered to be used metaphorically, any place preposition that is not used in its strict locative sense should be counted as a metaphor.

APPENDIX D

A SAMPLE SCORED BY THE SECONDARY RATER

Figure 12.13
These electrical motors are part of a power laboratory for electrical engineering students.

Electric potential always drops by the amount IR as current travels through a resistor. This drop occurs in the direction of the current.

In a generator or battery with current flowing negative to positive, the positive terminal will be E above the negative terminal minus the voltage drop due to internal resistance between terminals. There will always be some energy converted to heat inside a battery or generator no matter which direction the current.

When a battery or a generator is driving the circuit, the internal current passes from the negative to the positive terminal. Each coulomb of charge gains energy E from chemical or mechanical energy but loses IR in heat dissipation. The net gain in joules per coulomb can be determined by $E - IR$.

For a motor or a battery being charged, the opposite is true, because the internal current passes from the positive to the negative terminal. Each coulomb loses energy E and IR. The combined loss can be determined by $E + IR$.

In the case of a motor, the quantity E is commonly called *back-emf* (the electromotive force, or potential), since it represents a voltage that is in a direction opposite the current flow.

Figure 12.14 shows a circuit wherein a battery is being charged by a generator. E_G, E_B, R_G, and R_B indicate the potentials and internal resistances, respectively, of the generator and battery. Each coulomb that flows around the circuit in the direction of the current I gains energy E_G from the generator and loses energy E_B in the form of chemical energy to the battery. Heat dissipation is realized as IR_G, IR_1, IR_B, and IR_2.

APPENDIX E

WORDS USED AS METAPHORS IN THE EIDE CORPUS

Simple Replacement Nouns

Types	Ratio	Types	Ratio
step	3.18	strength	0.22
current	1.75	structure	0.22
work	1.64	adoption	0.11
point	1.42	advance	0.11
way	1.42	balancing	0.11
base	1.31	borrowing	0.11
flow	1.20	bubble	0.11
drift	0.88	closeness	0.11
source	0.88	cloud	0.11
body	0.77	computer	0.11
branch	0.77	constraint	0.11
memory	0.77	construction	0.11
balance	0.66	cube	0.11
flowchart	0.66	deadline	0.11
population	0.66	depth	0.11
regression	0.66	drawback	0.11
area	0.55	foot	0.11
basis	0.55	feed	0.11
conductor	0.55	growth	0.11
field	0.44	hand	0.11
shell	0.44	hardware	0.11
approach	0.33	horsepower	0.11
block	0.33	knocks	0.11
direction	0.33	length	0.11
impact	0.33	longhand	0.11
network	0.33	nearness	0.11
scatter	0.33	net	0.11
slug	0.33	overlap	0.11
software	0.33	overview	0.11
square	0.33	peak	0.11
boldface	0.22	perspective	0.11
carrying	0.22	play	0.11
couple	0.22	position	0.11
forerunner	0.22	proliferation	0.11
freshman	0.22	revolution	0.11
level	0.22	shortcomings	0.11
line	0.22	stage	0.11
mainframe	0.22	standpoint	0.11
passage	0.22	strides	0.11
scope	0.22	teeth	0.11
skeleton	0.22	wealth	0.11

Genitive Nouns

Types	Ratio	Types	Ratio
center	0.44	arm	0.11
basis	0.22	crust	0.11
life	0.22	foundation	0.11
life-cycle	0.22	head	0.11
role	0.22		

Anaphoric Reference Nouns

Types	Ratio	Types	Ratio
point	0.44	drop	0.11
step	0.22	field	0.11
way	0.22	stage	0.11
advance	0.22		

Verbs

Types	Ratio	Types	Ratio
base	0.66	couple	0.11
follow	0.66	creep	0.11
illustrate	0.66	downgrade	0.11
flow	0.44	draw	0.11
yield	0.44	drop	0.11
arise	0.33	dwell	0.11
balance	0.33	exercise	0.11
construct	0.33	extend	0.11
lead	0.33	fly	0.11
overcome	0.33	focus	0.11
view	0.33	glance	0.11
capture	0.22	iron	0.11
drift	0.22	lend	0.11
face	0.22	lie	0.11
fall	0.22	look	0.11
feel	0.22	lower	0.11
grow	0.22	neck	0.11
look	0.22	orbit	0.11
rise	0.22	outline	0.11
adopt	0.11	point	0.11
advance	0.11	put	0.11
approach	0.11	reach	0.11
arrive	0.11	return	0.11
bear	0.11	save	0.11
build	0.11	see	0.11
clarify	0.11	shift	0.11

Verbs, cont.

Types	Ratio	Types	Ratio
convey	0.11	skip	0.11
spawn	0.11	survive	0.11
stand	0.11	tie	0.11
stem	0.11	trace	0.11
stray	0.11	turn	0.11
stress	0.11	underlie	0.11
strike	0.11	undertake	0.11
support	0.11	visualize	0.11

Adjectives

Types	Ratio	Types	Ratio
positive	1.09	flexible	0.11
negative	0.99	full	0.11
high	0.88	global	0.11
higher	0.77	hard	0.11
low	0.77	lowest	0.11
poor	0.44	near	0.11
clockwise	0.33	neutral	0.11
counterclockwise	0.33	orbiting	0.11
large	0.33	pronounced	0.11
larger	0.33	raw	0.11
orbital	0.33	shorter	0.11
close	0.22	sinking	0.11
highest	0.22	small	0.11
lower	0.22	solid	0.11
overall	0.22	straightforward	0.11
short	0.22	strong	0.11
shortened	0.22	superior	0.11
smaller	0.22	sweeping	0.11
smallest	0.22	toothed	0.11
advanced	0.11	wide	0.11
apparent	0.11	wider	0.11
balanced	0.11	worth	0.11
broad	0.11	worthwhile	0.11
closer	0.11		

Adverbs

Types	Ratio	Types	Ratio
widely	0.33	largely	0.11
abreast	0.11	negatively	0.11
ahead	0.11	over	0.11
beyond	0.11	overly	0.11
fully	0.11	sharply	0.11
highly	0.11	smoothly	0.11
hard	0.11		

Place Prepositions

Types	Ratio	Types	Ratio
in	28.81	through	0.44
*on	3.50	*up	0.44
at	1.31	against	0.33
between	1.20	toward	0.33
into	1.09	off	0.22
from ... to	0.88	upon	0.22
*out	0.77	above	0.11
under	0.66	below	0.11
over	0.44		

* The syntax of two part verbs with particles differs from that of prepositions. The semantic similarities, however, motivates the inclusion of these particles here. Four instances of "on," four instances of "out," and one instance of "up" are particles of phrasal verbs.

APPENDIX F

WORDS USED AS METAPHORS IN THE BURGHARDT CORPUS

Simple Replacement Nouns

Types	Ratio	Types	Ratio
area	1.78	blackbody	0.11
field	1.78	branch	0.11
way	1.47	breakthrough	0.11
advance	1.36	carrier	0.11
software	1.16	chunks	0.11
step	1.05	concert	0.11
hole	0.94	contact	0.11
memory	0.84	drawback	0.11
key	0.63	edge	0.11
weight	0.63	entry	0.11
basis	0.42	environment	0.11
current	0.42	executive	0.11
flow	0.42	expansion	0.11
mainframe	0.42	fatigue	0.11
view	0.42	gains	0.11
blueprint	0.32	ground	0.11
body	0.32	guidelines	0.11
constraints	0.32	hand	0.11
fleet	0.32	heading	0.11
hardware	0.32	housing	0.11
level	0.32	inflation	0.11
line	0.32	interface	0.11
point	0.32	intertwining	0.11
spreadsheet	0.32	landscape	0.11
structure	0.32	menu	0.11
support	0.32	net	0.11
viewpoint	0.32	overflow	0.11
advancement	0.21	panorama	0.11
base	0.21	pathfinder	0.11
board	0.21	pie	0.11
clarity	0.21	piece	0.11
connections	0.21	progress	0.11
construction	0.21	revolution	0.11
course	0.21	route	0.11
impact	0.21	scope	0.11
keyboard	0.21	shift	0.11
overview	0.21	spectrum	0.11
path	0.21	square	0.11
pressure	0.21	standstill	0.11
stage	0.21	stride	0.11
standing	0.21	tree	0.11
wear	0.21	unevenness	0.11
weighting	0.21	watershed	0.11
world	0.21	wavelength	0.11
arena	0.11	wealth	0.11
balance	0.11	work	0.11

Genitive Nouns

Types	Ratio	Types	Ratio
heads	0.63	hardware	0.11
base	0.32	heart	0.11
floor	0.32	height	0.11
role	0.32	identity	0.11
background	0.21	life	0.11
body	0.21	link	0.11
root	0.21	outline	0.11
birth	0.11	seat	0.11
boundary	0.11	self-interest	0.11
breadth	0.11	side	0.11
crown	0.11	software	0.11
depth	0.11	tails	0.11

Anaphoric Reference Nouns

Types	Ratio	Types	Ratio
area	1.05	connections	0.11
step	0.73	field	0.11
point	0.42	juncture	0.11
constraint	0.21	level	0.11
tree	0.21	movement	0.11
advance	0.11	path	0.11
approach	0.11		

Nouns in a Copula

Types	Ratio	Types	Ratio
areas	0.11	lifeblood	0.11
decay	0.11	structure	0.11

Verbs

Types	Ratio	Types	Ratio
view	0.63	emerge	0.11
follow	0.52	engage	0.11
lead	0.52	enter	0.11
look	0.52	equip	0.11
process	0.52	extend	0.11
see	0.52	fall	0.11
spend	0.52	fatigue	0.11
base	0.42	flow	0.11
expand	0.42	fuel	0.11
rise	0.42	gather	0.11
yield	0.42	grow	0.11
construct	0.32	harvest	0.11
focus	0.32	hold	0.11
illustrate	0.32	immerse	0.11
overlap	0.32	import	0.11
reflect	0.32	lie	0.11
arise	0.21	mislead	0.11
cover	0.21	outline	0.11
migrate	0.21	overcome	0.11
parallel	0.21	overestimate	0.11
pinpoint	0.21	overrun	0.11
reach	0.21	perform	0.11
support	0.21	play	0.11
advance	0.11	point	0.11
approach	0.11	pursue	0.11
arouse	0.11	run	0.11
arrive	0.11	shift	0.11
attach	0.11	show	0.11
balance	0.11	spring	0.11
blossom	0.11	strain	0.11
call	0.11	stress	0.11
collect	0.11	stretch	0.11
conjure	0.11	structure	0.11
connect	0.11	surface	0.11
delve	0.11	turn	0.11
descend	0.11	underlie	0.11
die	0.11	undertake	0.11
direct	0.11	wear	0.11
dope	0.11	weigh	0.11
elevate	0.11		

Adjectives

Types	Ratio	Types	Ratio
high	1.47	dropping	0.11
positive	0.52	excited	0.11
dark	0.32	fragmented	0.11
higher	0.32	fresh	0.11
negative	0.32	fuzzy	0.11
soft	0.32	handy	0.11
raw	0.32	harmonious	0.11
underlying	0.32	heightened	0.11
allied	0.21	jarring	0.11
based	0.21	largest	0.11
far	0.21	low	0.11
hard	0.21	lowest	0.11
large	0.21	medium-weight	0.11
poor	0.21	overcrowded	0.11
rough	0.21	oversimplified	0.11
small	0.21	regimented	0.11
smaller	0.21	smallest	0.11
broad	0.11	sound	0.11
broadest	0.11	time-saving	0.11
clean	0.11	undue	0.11
clear	0.11	upper	0.11
clear-cut	0.11	vital	0.11
closer	0.11	worthwhile	0.11
critical	0.11		

Adverbs

Types	Ratio	Types	Ratio
ahead	0.11	pivotally	0.11
clearly	0.11	positively	0.11
closely	0.11	softly	0.11

Place Prepositions

Types	Ratio	Types	Ratio
in	31.41	under	0.42
*on	4.73	*upon	0.32
from...to	1.47	at	0.21
*into	1.36	between	0.21
*up	0.52	through	0.21
*out	0.42	within	0.21
towards	0.42	over	0.11

* The syntax of two part verbs with particles differs from that of prepositions. The semantic similarities, however, motivates the inclusion of these particles here. One instance of "on," three instances of "into," two instances of "up," one instance of "out," and two instances of "upon" are particles of phrasal verbs.

APPENDIX G

WORDS USED METAPHORICALLY IN THE CORPORA

ARRANGED BY SOURCE DOMAIN

Nature

birth
blossom
branch
bubble
capture
cloud
current
deadline
decay
drift
fatigue
flow
flowchart
gather
grow
growth
harvest
horsepower
landscape
life
lifeblood
life-cycle
migrate
net
network
peak
proliferation
root
shell
source
spawn
stem
stray
survive
tree
yield
wavelength

Body

arm
body
foot
hand
head
memory
skeleton
tail
teeth

Path

advance
approach
arrive
block
course
creep
direction
follow
juncture
lead
line
overcome
passage
pathfinder
point
progress
route
short-comings
skip
standstill
step
stride
way

Structure

balance
balancing
base
basis
build
construct
construction
floor
level
mainframe
stress
structure
support
underlie

Field

area
arena
boundary
environment
field
in
position
standpoint
world

Sight

clarify
clear
focus
glance
illustrate
light
look
overview
panorama
perspective
picture
reflect
scope
see
view
viewpoint