INFORMATION NEEDS AND BEHAVIORS OF GEOSCIENCE EDUCATORS: A GROUNDED THEORY STUDY

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AN ABSTRACT OF THE DISSERTATION
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Geoscience educators use a variety of resources and resource formats in their classroom teaching to facilitate student understanding of concepts and processes that define subject areas considered in the realm of geoscience. In this study of information needs and behaviors of geoscience educators, the researcher found that participants preferred visual media such as personal photographic and digital images, as well as published figures, animations, and cartoons, and that participants bypassed their academic libraries to meet these information needs. In order to investigate the role of information in developing introductory geoscience course and instruction, a grounded theory study was conducted through a qualitative paradigm with an interpretive approach and naturalistic inquiry. The theoretical and methodological framework was constructivism and sense-making. Research questions were posited on the nature of geoscience subject areas and the resources and resource formats used in conveying geoscience topics to science and non-science majors, as well as educators' preferences and concerns with curriculum and instruction. The underlying framework was to investigate the place of the academic library and librarian in the sense-making, constructivist approach of geoscience educators.

A purposive sample of seven geoscience educators from four universities located in mid-western United States was identified as exemplary teachers by department chairpersons. A triangulation of data collection methods included semi-structured interviews, document reviews, and classroom observations. Data were analyzed using the constant comparative method, which included coding, categorizing, and interpreting for patterns and relationships. Contextual factors were identified and a simple model resulted showing the role of information in teaching for these participants. While participants developed lectures and demonstrations using intrapersonal knowledge and personal collections, one barrier was a lack of time and funding for converting photographic prints and slides to digital images. Findings have implications for academic librarians to provide more visual media or assistance with organizing and formatting existing outdated media formats and to create collaborative collection development through repackaging personal collections of geoscience participants to enhance teaching. Implications for library school educators include providing curriculum on information needs and behaviors from a user's perspective, subject specialty librarianship, and internal collaborative collection development to complement external collection development.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The aim of this research was to investigate the information needs and behaviors of geoscientists in an academic work environment. While in the past, library and information science (LIS) research on information uses and users have focused on scientists and engineers (Wilson, 1994), few information user studies have specifically included geoscientists (Case, 2002). A generalized profile has resulted on literature and library uses and communication styles of scientist and engineers; nevertheless, some researchers do not agree that scientists and engineers are a homogeneous group (Seggren, 1995). Allen (1993) contrasted scientists and engineers broadly through differences in education requirements, career orientations, communication behaviors, socialization of subcultures, and personalities (p. 36). While Wilson (1977) stated “that occupational role is the most important single clue to understanding personal information gathering” (p. 50), Garvey (1979) stated that the “same scientists play different roles, have different needs, and respond differently to the same information” (p. 3).

This research was designed to collect data directly from geoscientists and involve participants in the interpretation of their perception of the role of information in their work tasks. Contrasting research approaches and methods are used to investigate information needs and behaviors of scientists and engineers. Focusing research on the use of information is a system-centered approach, while focusing research on the information user is a person-centered approach (Case, 2002). While "the main strategy for determining what information has actually been used over the past fifty years has been citation analysis" (T. D. Wilson, 1994, p. 27), researchers have suggested that studies of information users in the geosciences should collect data directly from the person under study (Bichteler & Ward, 1989; Gralewska-Vickery, 1976).

Specifically, the goal of this research was to examine the information needs and behaviors of geoscience educators related to developing course and instruction. Case (2002) stated that most traditional information-seeking studies involve "laboratory scientists, engineers in private firms, or university research faculty" (p. 35). Case reviewed information use and user studies and mentioned only two on information needs and behaviors of geoscientists (p. 235). While this shows a paucity of person-centered research on geoscientists, there is an abundance of system-centered studies on their use of information collections and services conducted by geoscience specialty librarians who primarily employed survey questionnaires and citation analysis (Derksen & O'Donnell, 1995). Hence, the overall problem is that LIS researchers have paid less attention to soliciting the geoscientist's point of view and that little research is focused on information challenges associated with geoscientists' teaching roles, specifically geoscience educators at post-secondary college and university work environments. If the ultimate value of a library is "measured by how effective it is for the educators," as DeFelice (2000) believes is the badge of success for a focused special collection digital library (p. 91), then a gap in the library and information science literature exists.

Research Questions

The general aim of this grounded theory study was to develop a model of the information needs and behaviors of geoscience educators who assume a teaching role within an academic work environment. A qualitative design with an interpretive approach and naturalistic inquiry was adopted to contribute new knowledge about the information world of geoscience educators. These research questions guided the study:

1. What academic subject areas do geoscience educators use for introductory geoscience curriculums?

2. What resource formats do geoscience educators use in introductory geoscience courses?

3. What are the information preferences, priorities, and concerns of geoscience educators?

Research questions were formulated to engage the participant to discuss the teaching process in order to show the role of information in the development of course and instruction. As geoscience educators explained the nature of geoscience information that educators consider vital to present to students, the information sources they find useful, and their preferences and concerns, participants' responses may affirm the constructivist and sense-making approach geoscientists use in the field as described by Force (2002).

The goal of this research is to aid practitioners, namely academic, private industry or governmental librarians serving in the roles of collection management, liaison, reference, and archives, to better understand the spectrum of geoscience and geoscientists' needs to enhance collections, systems, services, and facilities. Additionally, research findings will aid library and information science educators to improve curriculum to better prepare subject specialist librarians to recognize the importance of identifying information user needs and behaviors over merely describing and counting information use. Thus, in essence, the underlying questions are:

1. What is the place of the library and librarian in the sense-making, constructivist approach of geoscience educators?

2. What are the resource formats and instructional delivery styles that are made explicit in the sense-making constructivist approach of geoscience educators?

Background of the Study

John Henry Newman referred to the ancient designation of a *Studium Generale* or "School of Universal Learning" when he defined the idea of a university and described it as "a school of knowledge of every kind, consisting of teachers and learners . . . a place for the communication and circulation of thought" (Eliot, 2001). According to Newman, in a university setting "one generation forms another. . . . inquiry is pushed forward, and discoveries verified and perfected, and rashness rendered innocuous, and error exposed, by the collision of mind with mind, and knowledge with knowledge" (Eliot, 2001). The university library complements this mission. Norman Cousins (1915-1990), an American editor and writer said it best, "A library, to modify the famous metaphor of Socrates, should be the delivery room for the birth of ideas-a place where history comes to life."

Budd (1998) described the academic library as an ancillary institution; that is, its purpose is defined by supporting the mission, goals, and objectives of its parent institution, the university. Thus, the library assumes a central role in university life when research and educational goals are supported, which suggests that the information needs and behaviors of educators and students to promote teaching and learning are facilitated.

Understanding information uses and users in various disciplines should enhance the purpose of an academic library. Some LIS studies have failed to differentiate between occupations and work environments of academic professions and this does little to improve understanding of information users (Pinelli, 2001). Dervin and Nilan (1986) argued that clarification of differences among information user communities was important; nevertheless, more than ten years later, research findings by Winston (2001) show that science and engineering librarians reported having few subject specialty courses with which to learn about information users in their LIS education, and Hallmark (1998) found that course specialization rarely goes into specific disciplines such as geology. While geoscientists have some of the same information needs and behaviors of other scientists and engineers, contrasts do exist as Hallmark (1995) reported when contrasting chemists and geologists. As might be expected, the degree to which academic librarians believe geoscientists fit a generalized profile for scientists, engineers, or both, has significant impact on the information world of geoscience educators (Pruett, 1982; Hallmark & Limbo, 2003).

Case (2002) provided a thorough summary of scholarly research on the information world of library and non-library users. Among numerous studies conducted on scientists and engineers, Case reviewed only two involving geoscientists, Bichteler and Ward's 1989 exploration of the information needs and seeking behaviors of geoscientists (p. 235) and Gralewska-Vickery's 1976 investigation of Earth science engineers (p. 233). These two examples illustrate that geoscientists practice in both science and engineering realms and work in academia as both researcher and teacher.

University Disciplines and Educators

In order to examine information needs and behaviors of geoscientists who work in a university teaching occupation, an overview of higher education must be considered to provide a better understanding of the educational environment of this group. University educators are professionals who have extensive training in the culture and knowledge structures or core content of a discipline (Bruner, 1996). Dressel and Mayhew (1974) define a discipline by a core body of knowledge and accepted theory, a logical taxonomy and specialized vocabulary, and a systematic research strategy with common techniques for replication and validation. Donald (1990) maintains that university educators have a "responsibility for the development of our disciplines and for guiding the learning of the next generation of experts in our fields" (p. 242). Thus, educators will have information needs and behaviors for both research and teaching.

University educators develop curriculum and instruction to provide students with a sense of the discipline. Buchel and Coleman (2003) describe the process in a manner similar to information organization in libraries. A discipline is defined by subjects with educators identifying topics within the subjects to cover in a course; topics are divided into classes or concepts, and relationships among concepts are discussed and taught via lectures and activities (Buchel & Coleman, 2003, p. 4). Donald (1983) concluded that introductory courses exhibit the pivotal subjects or core content for a discipline, even though any one introductory course is unique to the educator and each educator adheres to a particular paradigm within which course material is developed (p. 32). In her research, Donald identified key subjects and concepts using document analysis of textbook and other curriculum materials, and examined taxonomy or relationships among concepts by interviewing instructors. In a similar method of defining core content, the nature of the geosciences will be identified according to geoscience educators.

In a later study, Donald (1990) explored another defining aspect of disciplines when she studied research strategies and contrasted validation processes and criteria between pure and applied fields of study. Validation processes are the standards used to validate knowledge; they are reflected in research methodologies and conceptual frameworks (Donald, 1990, p. 242). Donald acknowledged pure and applied research strategies differ and suggested that fields of study conducting pure research create disciplines, while fields of study conducting applied research will complement other disciplines by utilizing particular theory, vocabulary, and techniques (p. 243).

Two of the sets used by Donald (1990) were physics and engineering from physical sciences and psychology and education from social sciences. Although differences were found across disciplines in validation processes and in the importance of conceptual frameworks, Donald's results showed that the physical and social science examples did not differ significantly (p. 249). Interestingly, Ellis, Cox, and Hall (1993) came to a similar conclusion regarding the information-seeking behaviors of physical (i.e., physicists and chemists) and social scientists (p. 365) when the Ellis (1989) model for information retrieval design was applied.

Donald (1983) demonstrated that the structure of knowledge for a discipline is reflected in pivotal concepts presented by university educators through textbooks and course content, whereas Donald (1990) and Ellis et al. (1993) showed that research strategies utilized in disciplines are not exclusive to one field of study. Hence, disciplines show differentiation of core content and taxonomy, whereas research strategies may cross disciplines rather than strictly define disciplines.

Although research strategies crossing disciplines have implications for differences and similarities in information needs and behaviors for research, the actual impact is unclear for educators in a teaching role within a university setting. Donald (1990) suggested that both content and validation processes are needed to demonstrate the knowledge base of a discipline; she suggested that although preferred methodologies in disciplines may be obvious in research, they are often not adequately conveyed in teaching (p. 242). Bruner (1996) made this point also when he suggested that learning science is different from learning to be a scientist. Bruner mused that the university curriculum was a process that included props, pictures, texts, film, and demonstrations, yet instruction was an animated conversation on a topic that could never be fully defined. These researchers seem to suggest that educators presenting only disciplinary core content in curriculum development and instruction may give an inadequate representation of the discipline. This may be perpetuated in part by training, or lack thereof, given to university educators and the many duties and expectations of university educators beyond teaching.

Qualifications to become a university educator include the successful completion of course work, exams, and thesis or dissertation. Bruner (1983) described the process of American graduate education that gave him ..."the chance not only to think, but to think about thinking and to talk about thinking about thinking" (p. 292). Bruner described the journey to becoming a professional as a prescribed set of rituals and beliefs in the academic community in which one must learn the field, give papers, write up research, answer critics, know the literature, apply appropriate statistical tests, review important books for first-line journals, develop good academic manners, attend and contribute to department and faculty meetings (p. 283). Furthermore, if successful, then the given preferment is shown by tenure, grants, and attention in the literature (Bruner, 1983, p. 283). One important element absent from this review of qualifications for and description of university professionals is any mention of pedagogy. Whereas research is an expectation in academia, the latest profile of U.S. geoscience university faculty shows that research staff make up 8% of the total faculty ranks, and 63% and 29% are appointed to tenure-track teaching and adjunct faculty positions (Claudy, 2003, p. 14).

"Science faculty members have little, if any, professional training in teaching at the college level" (Sunal et al., 2001, p. 247). Sunal et al. found that little pedagogical training, combined with research and service traditions and expectations, made for challenges to educators that could contribute to the adoption of either a teaching-centered approach or lecture-test cycle for curriculum and instruction. McManus (2001) suggested that a teacher-centered approach to instruction requires little reflection on teaching and is the "traditional paradigm of higher education . . . centered on the classroom technique of a lecturing instructor transferring information to passive, note-taking students" (p. 423). In contrast, a learner-centered approach to instruction is "centered on the classroom technique of students' learning actively under an instructor's facilitation" (p. 424). McManus points out that teaching and learning take place under both methods but different assumptions about teaching lead to differing beliefs, values, and goals, as well as differing ways to achieve goals and assess results.

Not all educators employ the learner-centered approach. Faculty identified these barriers as preventing them from teaching science with a learner-centered approach: personal resistance to change, lack of training, and unavailable curriculum materials (Sunal et al., 2001, p. 247). General concerns cited for using, or not using, this instructional style include: (a) large class size, (b) weak student background or fear of science, (c) unqualified key personnel and colleagues uninterested in collaboration, and (d) tenure and promotion issues (p. 247). Educators cited lack of resources, time constraints, and turf conflicts as their most important concerns however (p. 247).

Regardless of teaching strategies used by educators, any perceived barrier to awareness, access, and acquisition of resources or any desire to collaborate in support of learning in and across disciplines is within the domain of academic librarians. Owusu-Ansah (2001) suggested that academic librarians go beyond custodial duties of collection management and collaborate with teaching faculty and students. As Kuh and Gonyea (2003) succinctly put it, academic librarians should facilitate "student engagement in learning." They state, the "shift in the focus of colleges and universities from teaching to learning" combined with "unfettered asynchronous access to an exponentially expanding information base" define the value of academia and academic librarians (p. 256).

Buchel and Coleman (2003) affirmed a need for traditional and digital libraries to support learning and in particular "acquisition and enhancement of scientific reasoning skills" (p. 4). They believed that although teaching through lectures and textbooks has been foremost in Western education, science education could be supported through key tools for library organization. They suggested that a faceted thesaurus might be a useful learning device, because of its organization by concept and relationship, as well as its classification and vocabulary categories (p. 6). For example, they compared concepts in a physical geography textbook with those of a major thesaurus in the geosciences and the Library of Congress (LC) and Dewey Decimal Classification (DDC) schemes. Although this novel technique warrants study, they reported that their example of the geography field was shown to be a marginalized knowledge domain in library classifications. GeoRef, at www.silverplatter.com/ catalog/gref.htm, did not have a major classification scheme devoted to physical geography and consequently; it contained only 35% of the concepts explained in the textbook (Buchel & Coleman, 2003). Likewise, physical geography concepts were excluded from the LC or DDC presumably because the concepts were neither subjects nor topics.

In another example of librarians supporting educators in teaching, Manuel, Molloy, and Beck (2003) conducted a survey on faculty attitudes regarding collaboration between their courses and library instruction. By choosing random faculty from different disciplines, Manuel et al. concluded that not all educators appreciated the librarian's role in promoting information literacy or in collaborative instructional ventures (p. 6). Faculty experiences in library learning, frequency of library use, publishing output and general satisfaction with the library seemed to have some relationship to receptivity of educators to formal library instruction (Manuel, Molloy, & Beck, 2003, p. 2). In a similar study, Hightower (1996) examined faculty attitudes, and found no correlation between faculty and undergraduate student library use patterns in a geology library setting. However, geology faculty most interested in collaboration had taught over 20 years and had requested library instruction for upper level, low enrollment courses (Hightower, 1996).

Even if academic librarians view their role as both information provider and educator, improvement of library services may depend upon changing faculty attitudes. The key to changing faculty attitudes about libraries and librarians may require changing the attitudes librarians hold about scientists and engineers. While information use and the information-seeking behaviors of scientists and engineers as a whole has been the focus of library and information science research for decades, Seggren (1995) contends that librarians need to know more about scientific and engineering communities to rethink and redesign reference and information services (p. 95).

Science and Engineering Communities

Although a common conclusion is that scientists and engineers do not use library collections, but rather seek information through colleagues, Hertzum and Pejtersen (2000) pointed out that engineers and scientists are a diverse group of professionals (p. 762). Allen (1993) cautioned that information use studies should not neglect the differences between science and engineering and "to treat both professions as one and then to search for consistencies in behavior and outlook is almost certain to produce error and confusion of results" (p. 39). King, Casto, and Jones (1994) summarized the breadth of engineers' information needs and behaviors studies, while Seggren (1995) summarized studies on scientists' behaviors. Although some researchers have criticized the literature on these groups as "fragmented and superficial" (Pinelli, Bishop, Barclay, & Kennedy, 1993, p. 167), it appears that contrasting engineering and science is essential to research on information needs, sources, and behaviors of educators.

Pinelli (2001) reported that researchers consistently find that engineers use information parsimoniously to solve problems and choose informal sources they perceive to be effective and efficient (p. 150). This task-oriented conceptual framework has led some to suggest that engineering is an applied subject and trade profession culturally inferior to science, whereas Hapgood (1993) argued that engineering is a scholarly academic discipline and profession akin to science. Science and engineering were described as reciprocals, one dependent upon the other in both an intellectual and a spiritual sense. "Engineering could be seen as a special case of science ('applied science'), but science could equally well be described as a special case of engineering ('abstract engineering')" (p. 50). Seemingly in contrast, Price (1965) wrote that treating engineering as an applied science is naïve, because engineering breakthroughs do not always result from particular scientific research (p. 563). However, Hapgood (1993) explained differences in a situational context: scientists, given a phenomenon, are asked to find its logical and physical relations to the rest of the universe, while engineers, given the physical relations, define the phenomenon and derive objects from these relations. Stated another way, "science is understanding where you are; engineering is getting there" (p. 50).

Pinelli (2001) stressed that engineers are not scientists and that these professionals differ in information tools and sources, knowledge production and use (p. 131, 143). Allen (1993) found that engineering journal literature does not build or accumulate as scientific literature does (p. 39). In science, publication is an end product and establishes priority, whereas in engineering, publication may be secondary to utilization of the innovation (p. 40). As an illustration, the Wright brothers were remembered for the airplane innovation, not scientific publications (p. 40).

When publication is secondary to innovation, information needs and behaviors respond accordingly. Hertzum and Pejtersen (2002) explained that "engineers search for documents to find people, search for people to get documents, and interact socially to get information without engaging in explicit searches" (p. 761). They suggested that this was caused by the nature of the information need in applied research, where the *answer* was not as important as the *process* and *context* of their particular work task (p. 761). Interestingly, Allen (1993) stated that "vendors are another important channel in technology because they are important potential suppliers of components or subsystems, and they provide information that they hope will stimulate future business" (p. 45). Likewise, textbook publishers and resource suppliers may act as the vendors or people relied upon for information needed by educators.

"The extent to which scientists and engineers differ in the degree to which they use oral and written channels can be seen even more clearly in comparing the way in which they allocate their time" (Allen, 1993, p. 45). Allen found that within research and development, the engineer placed more dependence upon colleagues while the scientist spent more time reading the literature (p. 46). Differences between work occupations and source preferences point to the need for librarians to examine information users to improve services and communication (Gralewska-Vickery, 1976). In order to understand information users working within the geosciences, an overview of the nature of the discipline and type of resources specific to geoscience must be considered to provide background information on educators working in the geosciences.

The Nature of the Geosciences

Geoscience is the study of the Earth, its systemic processes, and its place in the universe, according to a popular Earth science textbook (Tarbuck & Lutgens, 2003, p. 16). While geology is one primary disciplinary knowledge base in the geosciences, many specializations exist to analyze and interpret Earth's systemic processes and the universe. A subject specialist librarian explained that, "the geosciences include geology and its subdisciplines, the application of other physical sciences to the study of the earth, and the application of geology to practical problems" (Pruett, 1986a, p. 143). As the geosciences continue to evolve, specializations are created by collaborating beyond the physical sciences.

Pruett (1986a) distinguished the geosciences from other physical sciences in that all Earth sciences have a geographic or geospatial aspect and time or geotemporal dimension (p. 143). For instance, rock samples can be interpreted by locating them in some physical space such as solid Earth or in the universe (i.e., other planets and moons, or universal space for meteors), as well as correlating them to a past or present time such as assigning an absolute or relative date.

Classical geology is a historical, descriptive science in which geologists examine Earth's surface to understand its history and to describe its processes of formation. Pruett (1986a) explained that some of the factors contributing to understanding Earth's history and evolution have become subdisciplines of geology (p. 143). For example, the study of rocks is the petrology subdiscipline, while the study of rock layers involves stratigraphy or structural geology. Petrologists focus on genesis and descriptive identification of rocks, whereas stratigraphers and structural geologists study the sequence and deformation of rock layers.

In geology, data collection is followed by analysis and interpretation, giving rise to more geoscience disciplines through the application of other sciences to Earth science. For example, the geoscience discipline of geophysics was created to apply physics knowledge and procedures to geologic phenomena such as earthquakes or magnetic fields, whereas geochemistry applies chemical knowledge and procedures to geologic phenomenon such as age dating of rock and its component minerals using radioactive isotopes or geochronology (Pruett, 1986a, p. 144). In contrast, another set of specializations evolved when geologic knowledge was applied to practical needs. For instance, engineering geology applies geologic and civil engineering principles to locating and designing hazardous waste disposal sites, while petroleum geology applies geology to locating and extracting petroleum or oil and gas from underground reservoirs.

In all, the American Geological Institute (AGI) divides geosciences into eleven broad subdivisions and 94 teaching and researching specialty areas (Claudy, 2003, p. 14-15). These specializations are shown in Appendix A. The specialty areas are self-reported on a questionnaire used to compile a directory of geoscientists in university departments and governmental agencies (Keane, 2004). Although geology is one of the larger subdivisions within the geosciences, many specializations have developed from the application of other disciplines to geology and geology applied to other disciplines that have been grouped into subdivisions and numerous disciplines or subdisciplines with broad or narrow focus and situated within the geosciences.

Conceptual frameworks and theoretical foundations for geoscience have been articulated by Frodeman (1995), a philosopher and geoscientist, and Thagard (1992), a scientific historian. A unifying explanatory conceptual framework for geology evolved from the idea of continental drift, which was introduced in a 1915 book by the German meteorologist Alfred Wegener. Thagard made the case for the theory of plate tectonics as the "dominant framework for understanding geological phenomena," which began to be accepted in the 1960s (p. 157). In addition to foundations for geology, Frodeman asserted that some geoscience specialties are experimental and deductive-nomological with a postpositivist perspective, while other geoscience specialties are guided by a hermeneutic approach and inductive-interpretive reasoning that utilize historical narratives (p. 966).

Melhorn and Laffoon (1987) recognized that "geoscience crosses many interdisciplinary boundaries and involves literature based on both quantitative-numerical precision and traditional qualitative-historical data" (p. 3). They stated this in another way, "geologists have always suffered a form of scientific schizophrenia, for they have long recognized that geology differs from many of the other sciences," . . . "a historical science amidst a sea of hard sciences" (p. 3). Specializations drive the empirical-quantitative and historic-qualitative approaches to create a community of geoscientists and geoengineers united by a common knowledge domain originating with the study of Earth and its place in the universe. Consequently, the interdisciplinary knowledge domain and multiple methodological approaches for the geosciences shape both traditional and unique sources created and used by the geoscience community.

Geoscience Information Sources

The nature of an academic discipline may influence the array of information sources created and utilized to transfer information and knowledge. According to Regan (2000) geoinformation and data are experienced and gathered through observation and measurement of the natural world, which includes an interaction among the lithosphere, hydrosphere, atmosphere, and biosphere. Associating geoscience physical and digital artifacts with a geographic place and geologic time is necessary for interpretation. Regan detailed information sources including images, text, and data sources, electronic and print. Organization, dissemination, and preservation ensue in both formal and informal formats, while information, specimens, and data are housed in both internal and external environments such as home or office and museum or library.

A geoscientist's personal experiences and interpretations are communicated and accessed through a variety of formats. Allen (1993) categorized information sources as (a) informal, person-to-person relations; (b) formal, published literature and unpublished documentation; (c) raw data (p. 293). Informal source formats are defined as intangible and oral, and they include personal experiences and knowledge, as well as person-to-person interactions with colleagues, vendors, and students such as teaching. Formal source formats are defined as tangible and documented, including external representations or products either published for trade or non-trade. For example, trade would include articles published in journals for sale, while non-trade would include open-file reports for the public domain in governmental agencies such as the United States Geological Survey (USGS). Formal sources can be divided into primary or secondary. Primary sources include reports and archives, while secondary sources are databases and materials that provide the means for locating primary materials or synthesizing, clarifying, and criticizing primary source data (Mount, 1995, p. 23). Raw data are taken to mean both tangible and intangible specimens and products that may provide the substance for formal and informal sources.

Researchers and practitioners compiled examples of the different data and formal source formats used by geoscientists. The vast majority of publications on the use of information and resources specific to the geosciences are found in the annual proceedings of the Geoscience Information Society. Bichteler (1991), one of the few Library and Information Science (LIS) educators who specifically studied geoscientists, noted that the importance of geographical orientation meant geoscientists used region-specific publications that come out of national, state, regional, and local societies and governmental agencies, as well as private and public academia. In addition to the information and data found in books, journals, and other serials, geoscientists create and use maps; dissertations and theses; ground, aerial, and satellite photographs and images; oil and gas well logs; meteorological records; seismograms; rock, mineral, and fossil specimens; guidebooks; research newsletters; field and open-file reports (Bichteler, 1991; Pruett, 1982, 1986b). It is expected that educators use personal sources such as notes, images, and drawings, to create oral and electronic presentations for lectures and professional association meetings.

Geoscience resources are housed in private and public collections, that may be accessed through secondary sources such as abstracting and indexing services, bibliographies, reviews, standard reference materials, electronic source reports, search engines, and other product and service information. Although traditional geoscience literature sources are archived in academic libraries (Derksen, 1986; Dunn, 2001), some geoscience literature and raw data are likely to be found in state and federal geoscience surveys (Pruett, 1986; Sorensen, 1989), corporate libraries (Parris, 1986), digital libraries (DeFelice, 2000), and other governmental agencies or museums (Regan, 2000).

Bichteler (1991) identified many resources unique to geoscience as gray literature. Gray literature is a label assigned by librarians for resources that defy bibliographic control or are not found in catalogs, abstracts and indexes (p. 39). Although Van Styvendaele (1977) found that "abstracting and indexing journals are astonishingly unimportant" to academic scientists and he suggested they may "serve the needs of information scientists rather than those of researchers" (p. 271), his research, as well as other research concluding that geoscientists do not use abstracting and indexing databases, was conducted before electronic sources were commonplace (Bichteler & Ward, 1989; Gralewska-Vickery, 1976; Hurd, Weller, & Curtis, 1992). While some academic libraries purchase online database indexes, local and regional resources may be missing and indexes could be several years behind in adding newest publications (Bichteler, 1991). Examples of geoscience related databases include Applied Science & Technology (geology), General Science (Earth science), Biological & Agricultural Index (environmental science, paleontology, and soil science), and GeoRef. While GeoRef is a comprehensive geoscience database produced by AGI, which contains North American geoscience citations from 1785 and global citations from 1933, it is not inclusive as was shown earlier with the example of geography. Thus, awareness, access, and acquisition of geoscience sources may be problematic for both librarian and geoscientist because of gray literature status, the variety of public and private institutions and agencies housing the materials, and the breadth of primary formal information and data source formats.

Information and the Geoscientist

The information world of individuals and groups of individuals, such as geoscientists and geoscience educators, includes the characteristics and behaviors unique to people who have information needs and are looking for information. Information is ambiguous and can be thought of as a noun or verb. The same information may take on multiple meanings to different people, and information can lead to individual understandings or allow for the communication of knowledge to groups. Information can be transferred and exchanged as a commodity or process, although it is not always present in a tangible form. Information can be thought of as organized data external to intellect and knowledge as information internal to the intellect (Greer, 1987, p. 4). Regardless of whether information represents process or product, finding and using information are necessary skills and behaviors essential to humans and define their information world. Library and information science professionals are positioned to help or hinder these information needs and behaviors.

Geoscience professionals are distinguished by occupational roles and work environments. Teaching is an example of an occupation, while academia, business, consulting, and government agencies serve as examples of work environments for geoscientists (Earth Science World, 2004). Geoscientists are united by theory involving Earth and resource needs, yet divided by their various occupations, workplace and subject specialty research or teaching tasks. These differences suggest geoscientists are not a homogeneous group and information needs and behaviors may differ among individuals and sets of individuals.

Geoscience educators convey an understanding of the geoscience discipline to students through introductory geoscience curriculum and instruction. Academic librarians support these educators through a familiarity of the information world of geoscientists. Examining this world of information needs and behaviors and developing grounded theory will inform both educators and practitioners on a community of academic scholars within a university setting.

Specifically, the study will investigate the nature of the geoscience discipline and resources used to convey an introductory course, as well as needs and concerns of geoscience educators who perceive barriers to information awareness, access, and acquisition. This research examined the information needs and behaviors of geoscience educators who would be considered as exemplary teachers, and as such employed a constructivist, learner-centered perspective in their teaching. In this grounded theory approach research methods are framed with Dervin's (1992) sense-making and constructivism. Interpretations are compared and contrasted with various LIS information-seeking models aimed at professionals and interdisciplinary scholars.

Statement of the Problem

As pointed out earlier, library and information science research has been focused on the use of information collections and services of various scientists and engineers as a whole and less emphasis on the information user. Case (2002) pointed to only two information user studies that focused on geoscientists: Bichteler and Ward (1989a) and Gralewska-Vickery (1976). Both were conducted before electronic communication became commonplace. This shows a paucity of recent research specific to geoscience information users and indicates a tacit assumption that the information world of geoscientists may be analogous to that of other scientists and engineers. Over twenty years ago, Pruett (1982) warned of the scarcity of publications on the information needs of geoscientists (p. 29) and regrettably stated, "we [geoscience practitioners] have studied what is known about the communication behavior of scientists and the information behavior of engineers and looked at the ways geoscientists fit those patterns" (p. 41).

Pruett (1982) argued that geoscientists do not necessarily fit information user patterns of other scientists or engineers. Bichteler (1991) identified distinguishing features for geoscientists through the nature of the discipline and resources, and found that the diversity of subject areas and unique resource formats are acknowledged by librarians as gray literature and viewed with ambivalence (Bichteler, 1991, p. 39-40). Bichteler emphasized that gray literature defied mainstream bibliographic control and these resources are not found in any one single facility. Although data and information needed by geoscientists are increasingly digital and available online (DeFelice, 2000; Regan, 2000), years of poor bibliographic control may have created an inconsequential role for academic libraries and librarians in the information world of the geoscience educator.

The dearth of LIS person-centered research on geoscientists stands in contrast with an abundance of literature by specialty librarians. These practitioners' publications are a descriptive mother lode of the geoscience discipline, resources, and use of collections, systems, services, and facilities by geoscientists. However, the majority of these studies are on the use of information and situation specific to the researcher's library, and therefore, not on the information user. The preferred research methods were surveys, such as mailed questionnaires, or citation analysis (Derksen & O'Donnell, 1995). As Palmer (1991) pointed out though, counting and measuring the use of information sources, systems, or services in a library does not accurately depict information need (p. 105), so thus, little is known about the users from the user's perspective. This suggests that there is an abundance of system-centered research, yet a paucity of studies from the geoscientist's perspective about their information needs and behaviors.

There are strong indications that librarians and information professionals should learn about the nature of the geosciences and geoscientists from the LIS literature, graduate programs, and work experiences. With regard to LIS literature, Musser (1993) found that proceedings of the Geoscience Information Society, a primary publication venue on the information use and users in the geoscience community, were not included in traditional indexing and abstracting databases such as Library Literature. Even though these proceedings were found in GeoRef, a geoscience indexing database, this is not a likely place for librarians to search for LIS literature. Furthermore, Hjørland (2002) called for the discipline of information science to strengthen educational programs and resources to better prepare the information specialist to work in specific subject fields (p. 431). Hallmark (1998) pointed out that for the most part, "curriculum specializations, in graduate programs of library and information science do not extend to the level of specific scientific disciplines, such as biological, chemical, or geoscience information"

(p. 82). Finally, with regard to work experiences, Hallmark interviewed exemplary geoscience librarians who agreed that a "strong science background for geoscience information specialists was highly desirable, if not essential" (p. 84). Some library managers went so far as to say, they would rather "hire a geologist and train that person in library and information science than vice versa" (p. 84).

Most students come into library and information studies with undergraduate degrees in English or history and receive little training in subject specializations (Winston, 2001). Therefore, understanding geoscientists as information users may be more difficult than examining and describing their use of information. Hallmark and Limbo (2003) suggested that recruiting and training lies with library and information science schools. Hallmark (1998) stressed the need for graduate library programs to "place greater emphasis on knowing the users, their technical and research interests, and their information needs, as well as understanding and influencing users' information-seeking behavior" (p. 87).

Value to Library and Information Studies

The value of this study is to go beyond viewing the geoscientist's world of information in relation to use or non-use of a library's collection or facility and the use or non-use of a librarian's services or systems. Findings will highlight the disconnection between what geoscientists express as needs, where they go for this information, and what kind of results they experience *versus* common assumptions and perceptions of scientists and engineers' needs and behaviors reported in library and information science literature. As Seggren (1995) argued, in order to rethink and redesign reference and information services to a scientific community, more must be known. The value of this research will be a better understanding of the information needs and behaviors of geoscience educators to facilitate curriculum development and instruction in an academic workplace. This work complements and extends existing interpretations of geoscientists in the literature.

Findings will be valuable for academic librarians and future academic librarians who assist geoscience educators and offer exemplary service. A study that places greater emphasis on knowing users, by understanding contexts and influencing factors for information needs and behaviors, may be significant for library school educators who design courses to better prepare subject specialty librarians. Additionally, this research will create awareness among geoscientists of the latent importance of academic libraries and librarians to support their teaching. If the primary mission of a university is teaching, then library and geoscience educators must understand and communicate with one another.

Organization of the Dissertation

This chapter has provided an introduction to the dissertation, including the background of the study, statement of the problem, and research questions. Chapter 2 delineates the theoretical framework that guides the study. Chapter 3 reviews the relevant related research. Chapter 4 covers the research methodology, sample population, and techniques used in data collection. Chapter 5 explains results of data collection and analysis. Chapter 6 discusses the data analysis, conclusions from the study, and recommendations for future research.

CHAPTER 2

THEORETICAL FRAMEWORK

"To meet information needs of the user communities, information professionals must first understand the nature of the user community and become familiar with the information-seeking habits and practices of the user" (Pinelli, 1991, p. 5). In this grounded theory study, the information needs and behaviors of a small community of geoscience educators was investigated within the context of their teaching role in an academic environment. Although the aim of a grounded theory study is to posit a theory, existing theories and models are useful to review and may act as a means to either affirm research findings or reveal anomalies in current thinking. While theory is a "set of related statements that explain, describe, or predict phenomena in a given context," models identify and describe relationships among concepts (Case, 2002, p. 114). Thus, an overview of existing theories and models helps to situate geoscience educators within the greater community of human information needs and behaviors.

This study will be framed overall in a qualitative, naturalistic approach as suggested by Denizen and Lincoln (1998). This approach is imperative for investigating information needs and behaviors from the user's perspective, and stands in contrast to a quantitative approach in which findings are based on measuring a system's use. Additionally, the context in which these behaviors occur will be considered because as Dervin (1996) explained, context is on a continuum from the "carrier of meaning" to "a kind of container in which the phenomenon resides" (p. 14). For example, in Lillard's (2002) exploration of the information behavior of entrepreneurs who sell on eBay auctions online, it was the technology component or the system itself that was the context in which the phenomenon arose as well as inhibiting attributes affecting entrepreneurs' information behaviors. She reached her conclusions because she conducted a qualitative, naturalistic study and collected data directly from the entrepreneur's viewpoint. Lillard's conclusions could have been different if she had measured the system's use and suggested, because of the vast number of transactions, that eBay technology works for entrepreneurs.

Information needs and behaviors of geoscience educators can be viewed as emerging from teaching in a higher education environment. In order to investigate geoscientists' experiences in a teaching role, this study was conducted in the natural setting, specifically, the educator's office and classroom. To maintain the participant's normal context within their academic workplace was important to describe the holistic image of the role of information for geoscience educators from their viewpoint.

Understanding the methods educators use to convey the geoscience discipline through course and instruction assumes a constructivist perspective. This perspective means information is not merely transmitted; rather, meaning is constructed based on schema and examples from life and nature. Kuhlthau (1994) assumed a constructivist theoretical framework when she developed her Information Search Process (ISP). For her work, a constructivist approach was of critical importance because it is generic to human nature, not situation specific (p. xvii), and incorporates schema theory, which Kuhlthau believed described learning more accurately than a behaviorist or system-centered approach (p. xix). While Kuhlthau adopted a constructivist perspective to examine the student's process of learning, this researcher adopted a constructivist perspective to examine the process of teaching with a learner-centered emphasis.

Sense-making adds another dimension to the framework of this study. This perspective has its theoretical grounding in constructivism, and Dervin (1976) outlined the foundations for her Sense-making Theory some thirty years ago. At that time, she pointed out the contradiction or "almost disciplinary schizophrenia" among LIS researchers and practitioners with regard to units of study and methods (p. 324). Some researchers were looking for the *right* method to store *objective* information, whereas practitioners' experiences were indicating, "meanings are in people. . . . people construct their own reality. . . . no knowledge is absolute. . . . messages sent do not equal those received. . . . the same person is different across time and space" (p. 324).

By the 1980s, sense-making was representative of a major paradigmatic shift in library and information studies from a focus of system-centered to person-centered units of study and quantitative to qualitative-naturalistic research methods (Dervin & Nilan, 1986). Likewise, a shift in education has occurred for some, from a teacher-centered to learner-centered approach. As might be expected, this change creates a shift in information needs and behaviors accordingly and requires Library and Information Science (LIS) researchers to adjust their units of study and methods as well. For instance, Brown (1999) administered a forced-choice questionnaire and found educators in some science disciplines chose the textbook as a preferred source to support teaching. This conclusion does point to the use of formal sources but does not reveal information on teaching style or information needs and subsequent information behaviors. Brown's results may have been different if she had framed the study in sense-making and conducted interviews over questionnaires.

Sense-making rejects the view of information being merely transmitted and supports the view of information as an internal construction used to address a discontinuity or gap in knowledge (Dervin, 1992, p. 63). Dervin explained sense-making as a "theoretical net, a set of assumptions and propositions, and a set of methods which have been developed to study the making of sense that people do in their everyday experiences (p. 61). Hence, sense-making is both theory and methodology, and "an approach to studying the constructing that humans do to make sense of their experiences" (p. 67). Sense-making added another dimension to this study in both perspective and method.

In addition to a constructivist-sense-making theoretical lens with which to frame geoscience educators in their teaching role, relationships and connections of contextual attributes are proposed through models of information behavior. Several models will be reviewed including those posited by T. D. Wilson (1981), Kuhlthau (1994), Wilson and Walsh (1996), Leckie, Pettigrew, and Sylvain (1996), and Foster (2004). Although this is a grounded theory study, an overview of theory and models must be considered to provide a better understanding of the frameworks of phenomena in context, which may aid in confirming or interpreting findings.

Constructivism

Investigating the information needs and behaviors of geoscience educators requires examining experiences as they are understood by geoscientists who construct their views as framed through their educational and employment backgrounds. Taylor (1991) made the point that information "choices are based, not only on subject matter, but on other elements of the context within which a user lives and works" (p. 218).

While this investigation focused on the teaching concerns of a university geoscience educator, the educator assumes other roles in research and service, and she or he may have past work experience. These roles and backgrounds may directly impact the teaching phenomenon, which will be seen overall through a constructivist lens.

According to Force (2000), geoscientists produce and convey information using this constructivist perspective and therefore, it is important to explain this theory in some detail. Whereas Ernest (1995) divided constructivism into seven contrasting research paradigms, including traditional empiricism, information-processing theory, trivial constructivism, radical constructivism, sociocultural cognition, social constructivism, and social constructionism (p. 466), Littlejohn (1999) described constructivism as a process theory in a greater body of communication theories (p. 3). Process theories explain the mechanisms communicators use to produce and convey information (p. 107). The processes are related to constructing meaning by filtering reality through personal constructs which are organized into interpretive schemes (p. 113). In addition, "constructivism recognizes that constructs have social origins and are learned through interaction with other people" and consequently, culture is significant in determining meanings of events (p. 113).

For this study, constructivism is considered a theoretical lens regarding the nature of reality or how people understand the world around them and convey that understanding to others. A constructivist's view assumes words are tools of communication and coordination, not a property of a thing itself or representation reflecting one reality (Kivinen & Ristela, 2003, p. 368). Littlejohn (1999) recognized this movement was founded in the philosophy of pragmatism, which "stimulated a desire to improve society through widespread social change" (p. 4). Thus, constructivism has its early beginnings with the philosophical, educational, and psychological works of William James, John Dewey, and Frederic Bartlett, as well as more recent advocates including George Kelly and Jerome Bruner.

William James and Pragmatism

William James (1842-1910) was a philosopher who advocated pragmatism and a psychologist steeped in functionalism. In an introductory psychology textbook, Baars (1986) wrote that although James' beliefs were paradoxical in that his work was interpreted as advocating cognitivism and behaviorism, his writings on the nature of human cognition served as a foundation for constructivism (p. 400-401).

James (1955) noted that he was influenced by Charles S. Peirce, who first introduced pragmatism into philosophy as a specific doctrine in 1878 (p. 43). James explained his use of the term pragmatism to indicate a method for carrying on abstract discussions using inductive logic (p. 48). Using the pragmatic method, James suggested that if truths should have practical consequences, then in fact, the "truth of any statement *consists* in the consequences" (p. 230). Thus, he saw implications for this relativistic perspective in education, and James believed pragmatism would serve to "freeze out" teachers of the "ultra-rationalistic type" (p. 46). This was important to James who noted his views were consistent with the teachings of John Dewey and the humanism of Friedrich Schiller, who had both "suffered a hailstorm of contempt and ridicule" from supporters of rationalism (p. 54).

James (1955) wrote that learning was by doing and adopted the Greek translation of pragmatism meaning action (p. 43). Understandings that emerge from the application of concepts to action or practical experiences are pragmatic. James (1962) called this constructive process by which new knowledge was acquired apperception (p. 70), and he believed it to be synonymous with the process of education (p. 71). Thus, apperception was the process of constructing understanding and concepts as perceived in terms of previous experience, a guiding tenet of constructivism as concept learning theory.

James (1955) noted that pragmatism was an observable epistemology and he explained how an individual acquires new knowledge:

> The individual has a stock of old opinions already, but he meets a new experience that puts them to a strain. Somebody contradicts them . . . or he hears of facts with which they are incompatible. The result is an inward trouble to which his mind till then had been a stranger, and from which he seeks to escape by modifying his previous mass of opinions. . . . He saves as much of it as he can . . . until at last some new idea comes up which he can graft upon the ancient stock with a minimum of disturbance of the latter, some idea that mediates between the stock and the new experience. . . . This new idea is then adopted as the true one. New truth is always a go-between, a smoother-over of transitions. It marries old opinion to new fact so as ever to show a minimum of jolt, a maximum of continuity. . . . The reasons why we call things true is the reason why they are true, for 'to be true' means only to perform this marriage-function. (p. 50-53)

Thus, understandings and meanings are constructed and emerge from an application of concepts to directly experienced subject matter. In addition to these observations on constructivist learning, James (1962) stated that:

> the art of remembering is the art of thinking; and . . . when we wish to fix a new thing in either our own mind or a pupil's, our conscious effort should not be so much to impress and retain it as to connect it with something else already there. The connecting is the thinking; and, if we attend clearly to the connection, the connected thing will certainly be likely to remain within recall. (p. 70)

Thus, constructivism is an active instinct which enhances learning (p. 72) and makes connections to past experiences is the method. In contrast, verbal memorizing, according to James, was meaningless and simply a "parrot-like reproduction" (p. 73).

James (1955) stated that although . . . "an experience, perceptual or conceptual, must conform to reality in order to be true," reality means . . . "nothing more than the other conceptual or perceptual experiences with which a given present experience may find itself in point of fact mixed up" (p. 255). For James, actual or virtual truth that conforming experiences embody may be positive additions to previous reality or require adjustment to the way of knowing (p. 143). Thus, education represents a life-long learning process and truths are made in the course of experience.

John Dewey and Education

John Dewey (1859-1952) was a philosopher and an early proponent of educational psychology. Rieber (1997) called Dewey a representative of pragmatism and instrumental in developing the theory of cognition (p. 61). Kuhlthau (1994) credits

Dewey as one who provided the "philosophical foundation for viewing learning as a constructive process" (p. 15) from which she created the Information Search Process Theory. Kuhlthau (1994) stated, Dewey "recognized the critical role that education plays in a democracy. . . . that the basic nature of a democratic society is change and that the principle function of education is to prepare people for change" (p. 16). Preparing for change is important to people interacting in a contemporary information society and Kuhlthau believed that, "knowing how to learn is at the heart of education" (p. 16-17). In order to prepare people for change, higher thinking and problem solving skills are needed. Kuhlthau concluded that to be literate in an information society, knowing how to learn was a crucial and constructive process (p. 16-17).

To illustrate Dewey's constructivist theory of concept learning, he contrasted two educational psychology paradigms. Dewey (1956), writing in 1902, reported that psychology of "former days" regarded the mind as an "individual affair in direct and naked contact with an external world" (p. 98); whereas "contemporary psychology" conceived of the mind as a "function of social life-as not capable of operating or developing by itself, but as requiring continual stimulus" from society (p. 98-99). If the mind was to be "filled by direct contact with the world," as in the former days, then the needs of the learner would be met by presenting a "classified set of facts" with no social element found in this subject-matter (p. 100); consequently, "harmony between educational practice and psychological theory" would be preestablished so that facts, laws, and information were the "staple of the curriculum" (p. 101). In contrast, Dewey's contemporary psychology approach meant that "maximum appeal and full meaning in the life of the child" would occur when studies were presented "from the standpoint of relation they bear to the life of society" (p. 100). "To become integral parts of the child's conduct and character" studies must be assimilated (p. 100). "The older psychology was a psychology of knowledge, of intellect . . . emotion and endeavor occupied but an incidental and derivative place" (p. 101). Contemporary psychology promoted the construction of knowledge through the "study of natural objects, processes, and relations . . . placed in a human setting" (p. 140-141). Dewey's contemporary psychology paradigm embodied constructivism.

Dewey (1956) contrasted further between the two learning-teaching paradigms with the "modern conception of the mind" as a process of growth, while the older psychological theory presented a static view of mind (p. 102). A static mind needed only memorization drills "to complete a dependence upon the thought of others," which led to the belief that "the boy was a little man and his mind was a little mind" (p. 102). The newer psychology view of mind proposed changing and distinctive developmental stages "fueled by a social heredity" (p. 102). In the older psychological view, learned facts were assigned to a certain time of year for a course (p. 103). In contrast, Dewey's newer psychological view stated:

> The material is not presented as lessons, as something to be learned, but rather as something to be taken up into the child's own experience, through his own activities. . . . the aim, then, is not for the child to go to school as a place apart, but rather in the school so to recapitulate typical phases of his experience outside of school, as to enlarge, enrich, and gradually formulate it. (p. 106)

Dewey (1956) asserted that a static view of mind and learning did not encourage critical, reflective thinking and this traditional view, such as merely the presentation of physical facts, failed to . . . "engage his whole mental energy, but to confuse and distract him. . . . the original open and free attitude of the mind to nature is destroyed; nature has been reduced to a mass of meaningless details" (p. 141). In a traditional classroom, stress was placed upon the presentation of ready-made material for recitation. Dewey recognized the importance of reflection in learning that could lead . . . "the child to realize a problem as his own, so that he is self-induced to attend in order to find out its answer" (p. 149). Therefore, traditional education also neglected what Dewey called "voluntary attention" or a self-directed interest from the child (p. 149).

In addition to the reflective thinking and voluntary attention that enabled one to see connections and achieve a deeper understanding, the newer psychology of constructivism was learning by doing. Dewey (1956) reminisced that earlier generations spent their lives in continual training, creativity and constructive imagination, logical thought, and thus, acquired a sense of reality through first-hand contact with household and community (p. 10-12). These opportunities for connecting with nature changed with the "city-bred child of today" (p. 12), and thus schools responded by introducing manual training to supply the skills that were formerly taken care of in the home (p. 13).

In Dewey's time, only about one per cent of the entire school population attained higher education. This resulted in "cultured people" and "workers," a separation of theory and practice, that led some to question the value of education (Dewey, 1956, p. 27). Although Dewey (1956) believed school as an institution was valuable, he asserted there was waste in education:

> From the standpoint of the child, the great waste in the school comes from his inability to utilize the experiences he gets outside the school in any complete and free way within the school itself; while, on the other hand, he is unable to apply in daily life what he is learning at school. That is the isolation of the school-its isolation from life. (p. 75) What we want is to have the child come to school with a whole mind and a whole body, and leave school with a fuller mind and an even healthier body. (p. 80)

Therefore, for Dewey, the traditional view of education lacked opportunity for acting and reflecting on experiences, which led to waste in education. Dewey commented that even furniture contributed to waste in education in that the orderly arranged desks of a uniform size was conducive to listening and passive absorption of "uniform curriculum and method" (p. 31-32).

Thus, in education, teacher and text were central, not the learner and life of the student. Dewey (1956) felt revolutionary change was needed to make the learner the "sun about which the appliances of education revolve; he is the center about which they are organized" (p. 34). For Dewey and others, the problems inherent in the traditional view of education, were often most pronounced in the teaching of science.

Dewey (1956) divided science education curriculum into two aspects, "one for the scientist as a scientist; the other for the teacher as a teacher . . . . for the scientist, the subject-matter represents simply a given body of truth to be employed in locating new problems . . . carrying them through to a verified outcome" (p. 22). For the educator, science subject-matter needs to be a part of experience, "a related factor in a total and growing experience" (p. 23). Science subject-matter "stands outside" of the learner's present experience and the threat Dewey expressed was, "textbook and teacher vie with each other in presenting to the child the subject-matter as it stands to the specialist" (p. 24). Again, if the learner sees no connections between subject-matter and significance in life, "it is not a reality, but just the sign of a reality which might be experienced if certain conditions were fulfilled. . . . it remains an idle curiosity, to fret and obstruct the mind, a dead weight to burden it" (p. 25). Thus, Dewey was in favor of a constructivist approach to learning and to inform teaching practice, in order to eliminate idle curiosity and trivial facts presented *as* science education.

Frederic Bartlett and Schema Theory

Although James and Dewey introduced and developed many of the guiding principles of constructivism, Stuart-Hamilton (1995) credited Frederic Bartlett *(1886-1969)* with founding a constructivist theory based upon schema theory and his research on memory and perception (p. 25). Bartlett, a protocognitivist for his time, practiced and researched in a discipline dominated by behaviorist (Baars, 1986, p. 214).

According to Stuart-Hamilton (1995), Bartlett explained "that we use prior knowledge to shape our memories to fit in with how we expect the world to be" (p. 25). Constructivism as grounded in Bartlett's schema theory, "demonstrated that memories and perceptions are shaped by prior expectations" called schemata (p. 108). A schema or plan can make perception or memorization of an event easier because sense can be made of a known experience (p. 108). Schemata are not entities, but concepts implicit in our knowledge and created by the very environment that is being interpreted (Thagard, 1992, p. 19). Thus, schemata are organized sets of concepts "to infer that certain unobserved and unmentioned elements must be present" (Anderson, 1990, p. 195).

Bartlett (1932) used a descriptive case study approach to psychology research to show that past memories are biased mental reconstructions rather than direct recollections of observations. Bartlett provided the evidence for the role of schemata in memory with an experiment utilizing story telling. A Native American legend was told to non-Native American participants who were then asked to retell the story. Bartlett reported that recall was full of inaccuracies and omissions, and the gaps were filled in based on the participants' previous experience; he surmised this was the case because the participants came from a culture different from characters in the story (p. 66). Bartlett concluded, "Remembering is not a completely independent function, entirely distinct from perceiving, imaging, or even from constructive thinking, but it has intimate relations with them all" (p. 13). Therefore, schemata are the organizing information frameworks used to code and retrieve information and Bartlett's major contribution was that remembering is an interpretative and constructive process that has connections to familiar past experiences.

George Kelly and Personal Construct Theory

George Kelly (1905-1967) was a clinical psychologist who helped to define constructivist theory from a psychological perspective in order to inform practice and profession. Kuhlthau (1994) utilized Kelly's Personal Construct Theory as a conceptual framework to verify an information seeking and searching model for library and information instruction and reference services (p. xx, 14-23). Shapiro (1994) applied Kelly's constructivist approach to education, noting that students' ideas, beliefs, and expectations should be given high priority because their personal meanings are the bases upon which students create meaning during instruction (p. xiv-xv). Shapiro contrasted nicely the theory of personal constructs with behaviorism when she noted that the value of theory of personal constructs was in "seeing the person not as a set of drives or responses acting upon the universe, but as a person who views the world in his or her own unique manner and whose view has individual integrity" (p. xiv-xv).

Personal Construct Theory was created by Kelly (1955a; 1955b) as an attempt to merge a theory of personality with a theory of knowledge to arrive at new theory of personality or individuality based on role constructs. Constructs are patterns or guides that individuals create and attempt to fit over reality with which to view the world (Kelly, 1955a, p. 8-9). Kelly explained constructs in many ways. Constructs are patterns that are "tentatively tried on for size" (p. 9) and are the "channels in which one's mental processes run" (p. 126); constructs are "frameworks for making predictions" (p. 163), "interpretations of facts" (p. 136), and actually determine behavior (p. 9). Constructs are "the way things are construed as being alike and yet different" (p. 105) and constructs are not labels or stereotypes. Personal constructs belong to an individual and are unique to that individual; "constructs are personal and not easily shared" (p. 116). Constructs are built out of experiences and experiences are stored in the form of constructs; constructs can be guides to perception and behavior, and they aid in anticipating future events. Hence, constructs are patterns providing guidelines or frames of reference for making sense of the world. Forming new constructs and reorganizing old ones is a continual life process in learning with endless opportunity for change.

According to Kelly (1955a), constructs can be cognitive, affective, or action oriented, and theory formulation "emphasizes the creative capacity of the living thing to represent the environment, not merely to respond to it" (p. 8). When this behaviorist perspective-merely responding to the environment-is abandoned, a constructivist approach may be adopted where teaching and learning are considered the process of knowledge construction.

As new constructs are formed, the new information must be reconstrued to fit; the established constructs must be altered and expanded. In practice, Kelly (1955b) suggested the psychology of personal constructs be utilized as a means of achieving a therapeutic or reconstruction goal through enactment based upon role constructs (p. 1141). Enactment allowed the individual to develop an understanding of how others viewed the world and Kelly classified teaching as a casual pattern of enactment (p. 1142). Kelly recommended the application of Personal Construct Theory in educational psychology problems and the "classical teaching demonstration" be replaced with, for example, student learning "by playing the part of someone who is deeply involved in the problem which is being studied" (p. 1143). Kelly's example was that a student of American history could "role play" the part of George Washington at the Constitution Convention of 1787 and reach a level of understanding of history that might otherwise be problematic by simply reading the text (p. 1143). Supplanting conventional teaching practices with a constructivist approach and enactment activities could have important implications for student learning and teaching enhancement (p. 1143), as well as librarianship.

The fundamental postulate or underlying assumption of the psychology of personal constructs is that a person's learning processes are psychologically channeled by the ways events are anticipated. Bruner (1971) believed that "our knowledge of the world is not merely a mirroring or reflection of order and structure 'out there' but consists rather of a construct or model that can, so to speak, be spun a bit ahead of things to predict how the world *will* be or *might* be" (p. xi). Kuhlthau (1994) stated it another way, "Personal Construct Theory proposes that constructs are built out of a person's experience in order to anticipate future events" (p. 19). According to Kelly (1955a), constructive alternativism is the underlying philosophical position, and he explained it simply, "we assume that all of our present interpretations of the universe are subject to revision or replacement" (p. 15). Kelly considered each person to be a type of scientist, who intuitively formulates constructs about the world, collects data that confirm or disconfirm these constructs, and consequently alters her conception of the world to include the new information (p. 12-14). Thus, Kelly's research findings verified and refined the constructivist movement.

Jerome Bruner and Constructivism

Like the previously mentioned researchers, Jerome Bruner (1915-) rejected behaviorism and insisted psychology focus on how people *saw* the world and themselves rather than how they and their world *were* according to some objective criterion (Bruner, 1983, p. 69). Bruner (1983) identified stages of intellectual development, which invalidated the conditioned response of behaviorism in the human construction of knowledge. Bruner's stages of intellectual development were summarized as modes of representation: (a) enactive or thinking through action,

(b) iconic or thinking through images, and (c) symbolic or thinking through symbols (p. 143). Although the stages of development are not age specific, they were impacted by school and cultural environments. Bruner (1973) insisted a theory of development was dependent upon a theory of instruction. The role of an educator was to translate or convert knowledge appropriate to the learner's level so assimilation could proceed through a "spiral curriculum" where teaching builds upon an earlier student's understandings (p. 423-425). The student assumed the role of self-generated discovery in learning the material and developed a sense of the structure of that discipline. Depending upon their stage of development, the student organized this discovered evidence into hypotheses and reconstructed new information to fit or alter present states, eventually going beyond the information discovered or given. This discovery learning is contrary to memorization; Bruner believed memorized, unrelated facts were meaningless and . . . "curriculum ought rather to be built around the great issues, principles, and values that a society deems worthy of the continued concern of its members" (p. 424).

In addition to an individual or cognitive constructivism, Bruner insisted a sociocultural cognitive approach must be considered. An example of this was Bruner's (1996) model of mind that included two modes of thought: (a) mind as an information processing computational device; and (b) mind as established and understood in the use of culture (p. 1-3). Bruner believed culture shaped meaning and provided the toolkit for organizing and understanding the world (p. 3). Bruner explained that reality construction is shaped by traditional and cultural ways of thought and the role of educator was to aid students in learning to use these cultural tools. Bruner's advice to teachers was, "we must place ourselves inside the heads of our students and try to understand as far as possible the sources and strengths of their conceptions" (p. 49).

Therefore, Bruner's wisdom unfolded in the following manner. Acting in constructed worlds meant that acts of discovery led to acts of learning. Acts of learning led to acts of meaning and thus understanding allows for abstracting thought or going beyond the information given. Acts of learning encompassed three simultaneous processes: (a) acquiring new information which may be counter to or replace previous knowledge; (b) transforming knowledge to fit new tasks or realities; and (c) evaluating if the manipulated knowledge is adequate to the task or reality (Bruner, 1973, p. 421-422). Bruner noted that acts of discovery rarely happened on the frontier of knowledge, but rather from the "well-prepared mind;" acts of discovery were not dependent upon new information but required "rearranging or transforming evidence in such a way that one is enabled to go beyond the evidence to additional insights" (p. 402). This common thread throughout Bruner's career summarized constructivism as a theory of knowledge acquisition and concept learning such that, knowledge acquisition by the knower depends upon the knowledge getting process that is an active practice of the construction of knowledge.

Constructivism in Education and Information Delivery

It is generally assumed, education is, in its widest sense, a socialization process through which a person learns a way of life. Education involves interaction through a network of human relationships that combine with different disciplinary content and method to form the educational experience in a society.

For over 100 years, cognitive psychologists and philosophers including James, Dewey, Barlett, Kelly, and Bruner advocated change in viewing how people learn and in understanding human cognition. They envisioned a theory of learning that could apply to the work and school environments. In the spirit of these founding advocates, constructivism is a lens and theory for a learning-centered or person-centered paradigm that could to improve both education and librarianship.

Constructivism as a theory of learning informs educational delivery and expectations, in spite of researchers insisting constructivism is not a theory of teaching (Fosnot, 1993, p. vii; Windschitl, 2002, p. 136). According to Bruner (1986), the standard teaching-learning epistemology in the educational process has been . . . "one of *transmission* of knowledge and values *by* those who knew more *to* those who knew less and knew it less expertly" (p. 123). In contrast, Bruner described a constructivist's view of education delivery as:

> negotiating the world of wonder with the students and expressing meaning and culture as a forum . . . the learner becomes a part of the negotiatory process by which facts are created and interpreted. He becomes at once an agent of knowledge making as well as a recipient of knowledge transmission. (p. 127)

This negotiation process is one way to connect ideals of constructivism, or what is known about how people learn, with the education and the information search process to create a constructivist classroom or library environment. Constructivism is a perspective on learning advocated for educational reform (Brooks & Brooks, 2001,

p. vii; Fosnot, 1993, p. vii; Windschitl, 2002, p. 135) and could be the basis for improvement in librarianship.

Constructivism implies change, whether it is in the classroom or library settings. In education, the expectation is for the educator to shift in role from solely a transmitter of knowledge, who could stimulate and reinforce the correct response, to a guide or mediator for a learner's discoveries. The expectation for learners is long-term understanding rather than a perceived success as shown by standardized tests, which fail to distinguish between a student's short-term performances strategies from a deeper understanding and an ability to recall concepts over time. In librarianship, the shift is from merely providing physical access of resources to providing intellectual access and encourages the process of seeking meaning. Thus, whether the educator is library or science faculty, a constructivist approach will facilitate learning and sense-making through collaboration of learner, instruction, and teacher. The constructivists' view of teaching and service is that of a mediating role in sense-making.

Sense-making

The sense-making paradigm as articulated by Brenda Dervin has helped to reform research and practice in librarianship (Case, 2002, p. 288). Case described Dervin's sense-making was an essential perspective for describing information behavior and he called it a theory, methodology, and paradigm (p. 146). Sense-making emphasizes naturalistic methods and rejects approaches to information seeking that define information as a commodity transmitted to people. Sense-making is premised on the notion that people create meaning and social structure through interacting with others; that is, information is not a thing that exists apart from human behavior. Dervin's sense-making is grounded in the writings of Dewey, Kelly, and Bruner, who collectively provided the frame for sense-making as a way to assess detailed accounts of strategies people use in problematic situations to cope with stress and uncertainty.

Dervin's (1976) sense-making emerged from a belief that people do not control nature but seek to make sense of it based on an "unknown combination of information about reality and information that is the creative product of people" (p. 325). Dervin made the point that the same person may change across time and space; that is, when people are exposed to information such as in education or library systems they may adapt their personal constructs and change (p. 324). This simultaneous adaptation and creation process is the main premise behind models of human information behavior from a constructivist perspective and serves as the foundation for sense-making.

Sense-making developed in response to what Dervin (1976) identified as ten common and dubious assumptions among information providers (a) objective information is most valued (p. 327), (b) some information is good but more is better (p. 327), (c) "objective information can be transmitted out of context" (p. 328), (d) information is only acquired through formal sources (p. 329), (e) information is relevant to every need (p. 329), (f) "every need has a solution" (p. 330), (g) information access and acquisition is possible in every situation (p. 330), (h) sources available will meet information requested (p. 331), (i) situations of time and space can be ignored (p. 331), and (j) individuals make connections between external information and internal reality unaided (p. 332). These assumptions are based on a definition of information as an objective, external commodity organized and archived in information systems and facilities. McCreadie and Rice (1999a) identified these same context-specific conceptualizations, i.e., information as data in the environment and as resource or commodity, and they suggested this view of information is prevalent in LIS research literature where the unit of study has a system-centered orientation. Additional conceptualizations of information identified by McCreadie and Rice were information as representation of knowledge and information as part of the communication process. It is in the latter circumstance that Dervin has conceptualized sense-making.

Dervin (1976) realized that how the terms information and need were defined, sets in motion certain assumptions that may greatly effect mediation and facilitation by librarians and educators alike. If information is defined as subjective and internal, then it becomes both a pattern of reality with structure input by people and process of sense-making by which people are informed or instructed (p. 326). Consequently, Dervin suggested practitioners and educators must shift their thinking from an information system that "collects, stores, retrieves, and delivers information" to a communication system that would "help people inform themselves, create their own order, establish their own understandings, and cope with their own accidents" (p. 333). Researchers, who inform practitioners and educators, should turn their attention to knowing "what individuals do to make sense out of their worlds as they move from one event to another" (p. 333) and must accomplish this by obtaining answers from the user's viewpoint.

Dervin (1998) described her person-centered framework as a theoretical and methodological approach to investigate information needs and behaviors. Thus, sense-making conceptualizes information as a verb, or process of communication, not merely a noun, or commodity to capture, store, and retrieve; information is defined as the product of and fodder for sense-making and sense unmaking (p. 36).

Sense-making and Information Needs and Behaviors

Case (2002) called Dervin's work the most ambitious attempt of any researcher to explain the origins of information needs (p. 70). It is information need that may motivate behaviors of seeking and using information. Dervin (1992) specified a need arises from a situation, and the need suggests that a gap in understanding or knowledge has occurred; humans reach out for something they perceive as information sources to formulate ideas and answer questions (p. 68). Therefore, the gap is bridged when people use a help source and judge its worth (p. 68). A diagram representing Dervin's sense-making metaphor can be seen in Figure 1, which was adapted from Dervin (1992, p. 68-69). Dervin described each moment in a kind of sense-making triangle of need-gap-use as a new step because it occurs at a new time-space (p. 68-9). She suggested a micro-moment time-line interview for the core method to make sense of the situational events, gaps, and helps (p. 70). According to Dervin, this level of detail was used to identify information needs with emphasis,

> placed on understanding how the individual saw self as stopped, what questions or confusions he or she defined, what strategies he or she preferred for arriving at answers, what success he or she had in arriving at answers, how he or she was helped by answers (how he or she put the answers to use), and what barriers he or she saw standing in the way to arriving at answers." (p. 70)

SITUATION

↕

QUESTIONS

IDEAS FORMED

RESOURCES OBTAINED

↕

GAP ↔ USE

Figure 1. A Sense-making Diagram. Dervin envisioned a triangle of situation, gap, and use representing a person's journey in sense-making. When a situation creates information needs, questions are asked and answered. Ideas form and strategies arise to obtain resources to bridge a gap and satisfy the need. Sense-making is an awareness of the process involved in human information behavior or how people face barriers to understanding. Adapted from Dervin (1992, p. 68-69).

Thus, sense-making, as an approach to thinking about and implementing research or designing communication-based systems, has central foundational concepts of time, space, movement, gap, followed by step-taking, situation, bridge, outcome (p. 39). Dervin is not interested in the answer as much as the process of a person's encounter with a lack of sense in the environment and the desire to fill a knowledge gap.

Dervin (1997) stressed the need to focus on context or situational meanings because situational context makes a difference in the way people produce, organize, understand, seek, dismiss, and use information, as well as in the way an investigator approaches a study. Warning of the difficulty of defining context as a world view or in a methodological sense, Dervin (1997) noted flexibility in sense-making and added that choosing the in-between position was best. When context is viewed on a continuum, one end would define context as anything not defined as the phenomenon of study or in other words a container in which the phenomenon of study resides (p. 14). At the other end of the continuum, Dervin stated "context is the carrier of meaning" (p. 14).

Regardless of how they are defined, Case (2002) stressed the importance to consider context and meaning because "information needs do not arise in a vacuum, but rather owe their existence to some history, purpose, and influence" (p. 226). The information seeker has an external environment that "partially determines, constrains, and supports the types of needs and inquiries that arise" (p. 226). Dervin (1992) made this point when she argued that if attributes of status, demography, or personality predict sense-making needs, then information needs and behaviors will be restricted because there is a constraining force operating (p. 40). Along this same line, Palmer (1991) argued that a user's information needs and behaviors could not be discovered by counting and measuring the use of information sources, systems, or services in a library (p. 105). Hence, although the external environment such as an academic library should be considered, the use of a library's collection will not be primary in investigating an educator's needs and behaviors.

In addition, Case (2002) noted the information seeker has an internal environment of influence which includes memories, predisposition and motivations (p. 226). Palmer (1991) made this point, that scientists as information users in one organization with a common focus, were not an undifferentiated mass; "different sectors of the population have different expectations of an information service and require different treatment" (p. 125). Hence, by adopting sense-making as a perspective implies consideration of the influence of both the external and internal environments; and, by adopting sense-making as an approach encourages naturalistic and interpretive study methods. An approach such as sense-making should be able to explain information needs and behaviors, which has practical applications as well. McCreadie and Rice (1999) suggested that in order to improve systems and services for users, researchers should: (a) explore human behavior and cognition to avoid unintentionally created barriers to access; (b) enhance information retrieval by accounting for differential access, levels of experience, and factors such as time pressures; (c) account for situational contexts and information needs; and (d) account for the evaluation of utility of information, especially as it applied to information gaps, challenges, needs, or questions encountered in everyday life (p. 80-1). In addition to sense-making, predicting individual's actions in locating information has been explained and described through LIS models, which are currently used in librarianship.

Models of Information Needs and Behaviors

Models are designed to show factors and relationships among information needs and behaviors in order to provide librarians and other information specialists with a plan for mediating roles in the information search and sense-making processes. Although many models exist, attention will be given to T. D. Wilson (1981), Wilson and Walsh (1996), Kuhlthau (1994), Leckie, Pettigrew and Sylvain (1996), and Foster (2004). None of these models is meant to be a theory of information behavior, rather suggestions of the path and intervening characteristics individuals follow to move toward problem resolution.

Wilson Models of Information Needs and Behaviours

T. D. Wilson (1981) introduced a diagram in 1981 showing the circumstances that give rise to an individual's perception of an information need. Wilson identified personal needs and an individual's work role and environment as both the motivation for and barrier to information-seeking behavior (p. 9). These categories were factors involved in information needs are represented in Figure 2. Wilson defined three categories of personal needs as physiological, affective, and cognitive (p. 7) and suggested these needs can be satisfied with information or be the *trigger* for information-seeking behavior (p. 8). Wilson identified an individual's work role and environment as important considerations for information seeking strategies. Thus, Wilson believed these contextual factors were significant and must be recognized in information user studies as the motivations for information needs and information-seeking behaviors.

PERSONAL BARRIERS

Physiological Needs

Affective Needs

Cognitive Needs

↓

INFORMATION NEEDS

INFORMATION-SEEKING BEHAVIOR

↑ ↑

Work Role	Work Environment
Performance Level	Socio-cultural Environment
INTERPERSONAL	Politico-economic
BARRIERS	ENVIRONMENTAL BARRIERS

Figure 2. Factors Influencing Information Needs and Information-Seeking Behaviour.

Adapted from Wilson (1981, p. 8).

Wilson (1981) outlined the interrelationships among the areas of information studies with eleven components (p. 4). A representation of these relations is shown in Figure 3. At the top was the *information user* who has a *need* which may be nascent or may have come from previously acquired information that had provided *satisfaction* or *non-satisfaction.* The perceived need leads to *information seeking behavior* that moves to *demands on information systems* or *demands on information sources*. Accessing the systems or sources may end in *failure* where the information need is not met. Wilson showed this as a dead end. If information-seeking behavior did not make demands on systems or sources, it could lead to *information exchange* with *other people*, i.e., if the need was not met formally, then informally. Additionally, it could lead in the opposite direction to *information use*, and up to *satisfaction* or *non-satisfaction* and down to *information transfer* which also led off to *other people*.

Wilson reprinted these two diagrams in 1994 with slight modification, and began to refer to the diagrams as a model of circumstances that give rise to a need (p. 33). The motivational needs and barriers incorporated Ellis' (1989) model for information-seeking behavior (Wilson, 1994, p. 33). One modification was that Wilson's newly revised model included *success* as a possibility when accessing systems and sources (Wilson, 1994, p. 16). Success could then point the information user to *information use.* Information use cycles the user on to information that is *satisfactory or non-satisfactory*, which goes back to the beginning to an *information need.* Additionally, if accessing systems and sources ends in success, then information use can lead to *information transfer* with *other people* and *information exchange*. Wilson's

INFORMATION USER
↓
SATISFACTION → NEED
NON-SATISFACTION ↓
↑ INFORMATION ↔ INFORMATION
INFORMATION ← SEEKING BEHAVIOR EXCHANGE
USE ↕
↓ INFORMATION ↑
↓ ↓
SYSTEMS SOURCES
↘ ↙
INFORMATION PEOPLE
TRANSFER FAILURE ↑
↓
→ → → → →

Figure 3. Wilson's Model of Information Flow. Wilson created a kind of flow chart to generalize steps in satisfying information needs. He attempted to simplify a complicated process that involves people transferring and exchanging information among each other and through demands made on information systems and sources. He recognized this process can end in failure. Adapted from Wilson (1981, p. 4).

acknowledgement of information transfer and information exchange with other people formally recognized the importance of informal sources and interpersonal communication networks.

Wilson and Walsh (1996) republished Wilson's 1994 diagrams and referred to one as a general model of information-seeking behaviour and the other as a "model of circumstances that give rise to information-seeking behavior" as it appeared in conjunction with Ellis' (1989) model. A representation of the model is shown in Figure 4. Wilson and Walsh stated three main elements of Wilson's model as (a) "the situation within which a need for information arises (the *person* performing a *role* in an *environment*)," (b) "the barriers that may exist to either engaging in information-seeking behaviour or in completing a search for information successfully," and (c) "information-seeking behaviour itself" (p. 1). Although the simplicity of Wilson's first diagrams or models provided a "map of the area," as Wilson (1999) put it, he criticized his own work for not suggesting causative factors in information behaviors (p. 251). Wilson and Walsh did introduce intervening variables and a revised general model of information behaviour at this time. Although the Wilson and Walsh (1996) paper is now available online, it was first published in print as "a report of a review of the literature" by the British Library Board and not widely circulated.

The work of Wilson and Walsh (1996) was republished by Wilson in 1997 and 1999; the two models for information-seeking behavior appeared unchanged in these later publications (Wilson, 1997a, p. 552, 569; 1999, p. 252, 257). Although the newer models were related to the earlier diagrams, Wilson's (1997a, p. 569; 1997b, p. 47;

```
CONTEXT OF        ACTIVATING                     ACTIVATING
INFORMATION →         ↓      → INTERVENING →        ↓       → INFORMATION
NEED                             VARIABLES                       SEEKING
  ↑              STRESS COPING       ↓          RISK REWARD         ↓
                    THEORY                         THEORY
                              PSYCHOLOGICAL          ↓            PASSIVE
  ↑                                  ↓             SOCIAL        ATTENTION
                               DEMOGRAPHIC        LEARNING           ↓
                                     ↓             THEORY         PASSIVE
  ↑                            ROLE RELATED                        SEARCH
                                     ↓                               ↓
                              ENVIRONMENTAL                        ACTIVE
                                     ↓                             SEARCH
  ↑                                SOURCE                            ↓
                             CHARACTERISTICS                      ONGOING
                                                                   SEARCH
  ↑                                                                  ↓
      ←      ←    INFORMATION PROCESSING & USE      ←       ←
```

Figure 4. Model for Information Behaviour. Adapted from Wilson and Walsh (1996) and Wilson (1997a, p. 569).

1999, p. 257) second model of information behavior is more explicit and complex, with a continuous loop and no dead ends. It emphasizes context and recognizes different types of search behaviors, both passive and active. In addition, he reiterated from the 1981 diagram that the cause of information needs and information-seeking could be cognitive, affective, or physiological (Wilson, 1997b, p. 39). This model has nineteen components and begins with *context of information need.* Information needs can be for nascent information or to clarify and confirm currently held information (p. 40). Wilson suggested that although not every need results in action, steps are taken when an individual experiences stress and a need to cope; this general motivation Wilson credits to Dervin's sense-making theory (p. 41).

Thus, what motivates one to make sense from the world is termed an *activating mechanism*. This mechanism or motivation for searching may be explained through *stress/coping theory*, which is in a drop down box under the activating mechanism box. Once explained, the activating mechanism leads into the *intervening variable* box. Intervening variables are barriers to seeking information (Wilson, 1997b, p. 42). There are four broad groups of personal characteristics, social/interpersonal, environmental or situational, and source/credibility, which are meant to explain what affects motivation (p. 42). The variables are *psychological* disposition, *demographic* background, social *role*, *environmental* variables, and *source characteristics*. These factors all appear in a linear fashion as a drop down box from the intervening variable box. Thus, Wilson suggested a person's personality, age or education level, economic situation, and work role may affect information behaviors (p. 42-44). Environmental factors or situational barriers include time, geography, and national cultures (p. 44), while information source characteristics include accessibility and credibility (p. 45). Intervening variables lead to a decision to act or the *activation mechanism*. This motivating mechanism explains why some sources are used through the *risk/reward theory* and to what extent people pursue a goal as identified by *social learning theory* and *self-efficacy theory*. Risk/reward theory is based on the prediction that "when choice alternatives are similar, search efforts will be reduced as the gains to be made are reduced" (p. 46). How an individual handles uncertainty is associated with self-efficacy or the sense of personal ability, which is a central concept of social learning theory (p. 46). Thus, these activating mechanisms lead to *information seeking behavior* that can include *passive attention*, *passive search*, *active search*, or *ongoing search*, based on whether or not an individual believes she or he can or cannot perform the behavior to produce an outcome; the individual could choose mere attention and no action or passive, active, and ongoing searches (p. 46). The search results in *information processing and use*, which cycles back to the *person-in-context* and to the beginning, a context of information need.

Kuhlthau's Uncertainty Principle and Model for Information Search Process

Kuhlthau (1994) used a series of five research studies of information-seeking and use to develop her model, which was grounded in the uncertainty principle that initiates the information-seeking process. Although information processing and use are cognitive, Kuhlthau (1988) insisted that affective (feeling) and physical (action) considerations intervened and that the search process was constructive. This was consistent with T. D. Wilson (1981, 1997a, 1997b, 1999). Kuhlthau applied constructivist theory, a combination of the writings of Dewey, Kelly, and Bruner, to understand how search and acquisition of information moved from uncertainty to completion or how the user constructs an understanding of the problem. Although her units of study began with young people in a K-12 grade setting, Kuhlthau has expanded her information users to include professionals such as securities analysists (1997) and lawyers (Cole & Kuhlthau, 2000). Kuhlthau (1994) proposed the uncertainty principle and Information Search Process (ISP) model as the basis for mediation between systems and users and promoted her model to design process-oriented library and information services.

Kuhlthau (1993) called the uncertainty principle the conceptual framework for the information search process, because the search for information is initiated by a lack of direction which creates feelings of uncertainty and confusion. The uncertainty principle is supported by six corollaries, which include process, formulation, redundancy, mood, prediction, and interest (p. 347-352). The *process* of searching for information involves the information user constructing meaning though both thoughts and feelings. *Formulation* continues the thinking realm which further develops and extends the topic under study. *Redundancy* involves an interplay of the expected and unexpected; too much new information causes anxiety, while too much redundancy causes boredom. *Mood* refers to an individual's attitude, while *prediction* refers to the series of choices taken following a particular action. *Interest* involves personal motivation and intellectual engagement and as interest increases uncertainty decreases.

The ISP is illustrated as a model that moves in a linear pattern and involves six components. It is represented in Figure 5. Information seekers transition from uncertainty to understanding on three levels of experience or feeling-affective, thinking-cognitive, and acting-physical (Kuhlthau, 1994, p. 126). *Initiation* is the beginning of

	AFFECTIVE	COGNITIVE	PHYSICAL
	↓	↓	↓
INITIATION	uncertainty	ambiguity	seeking
↓	↓	↓	
SELECTION	optimism		relevant
↓	↓		
EXPLORATION	confusion/doubt		information
↓	↓		↓
FORMULATION	clarity		seeking
↓	↓		
COLLECTION	direction	specificity	pertenent
↓			
PRESENTATION			information

Figure 5. Information Search Process. The searching progresses down the left column. Interacting factors are placed in one of three categories, affective, cognitive, and physical. Adapted from Kuhlthau (1994, p. 43).

the information search when individuals realize a need. This stage is accompanied by feelings of uncertainty, anxiety, and apprehension. *Selection* follows initiation when the task at hand is identified and approach planned. Although an individual has a vague focus, feelings of optimism accompany actions of exploring. *Exploration* is accompanied by feelings of confusion, frustration, and doubt. This stage involves investigating the problem at hand to obtain personal understanding and focused orientation. Locating and reading materials are the actions at this stage. A *formulation* stage follows where clarity is reached. Feelings of uncertainty diminish and confidence increases and Kuhlthau considers this the turning point in the process. Thoughts and focus become clearer and a perspective on the problem is formed. *Collection* refers to a stage with thoughts of a sense of direction, feelings of confidence and increased interest, and actions of seeking pertinent information and documentation. The final task in completing the search process is *presentation* or a resolution of the problem with satisfaction and feelings of relief. If the problem is not resolved, feelings of disappointment accompany this stage.

Leckie Model of Information Seeking for Professionals

Leckie, Pettigrew, and Sylvain (1996) reviewed LIS literature on engineers, health care professionals, and lawyers to arrive at a model for information seeking of professionals. They included teachers and librarians, among others, and used the term profession to mean "service-oriented occupations having a theoretical knowledge base, requiring extensive formal post secondary education, having a self-governing association, and adhering to internally developed codes of ethics or other statements of principle" (p. 162). Leckie et al. developed the model to aid information system and service database development for particular professions because they believed few researchers had focused on specific groups with notable exceptions such as Gralewska-Vickery's detailed study of Earth Science engineers (p. 163). They premised the model on the view that professionals are task-oriented, which requires setting and achieving goals to provide service to clients (p. 162).

Leckie et al. (1996) found four related themes in the literature. First, although professionals are united by an overarching role of providing expertise to clients, they work within specific environments that differ in organizing structures, goals, and cultures (p. 178-179). Second, in addition to a working context of the profession, the many roles of individual professionals must be studied in depth (p. 179). Third, the variety of work environments and multiplicity of roles are each embedded with specific tasks which create information needs (p. 179). Fourth, professionals are helped and hindered by complex and interacting variables that create a continuous loop; these variables include sources and awareness of information, as well as outcomes of the searching and seeking processes (p. 179). Thus, the process of determining information needs and seeking behaviors for Leckie et al. was intentional and directly related to work environments, roles, and tasks.

The model, shown in Figure 6, has seven components begining with the professional *work roles* that define related *tasks*. Tasks define *characteristics of information needs* that lead to *awareness of information* or *sources of information*. Regardless of direction, these two components converge on *information is sought*. From a central position in the model, the process can move to *outcomes*, or cycle back to characteristics of information needs. The six variables of the model are connected by

WORK ROLES

↕

TASKS

↕

← CHARACTERISTICS OF INFORMATION NEEDS →

↓ ↑ ↓

SOURCES OF		INFORMATION		AWARENESS
OF	→	IS	←	OF
INFORMATION		SOUGHT		INFORMATION
↕		↓		↕
FEEDBACK				FEEDBACK
↑				↑
←	←	OUTCOMES	→	→

Figure 6. Model for Information-Seeking Behavior of Professionals. Professionals produce services and this task-oriented work role is the context for information needs in this model. When the task serves to define the need, sources of information are sought and the outcomes lead to a new awareness. Awareness can lead to an outcome that point to sources. Adapted from Leckie, Pettigrew, and Sylvain (1996, p. 180).

arrows which are mostly unidirectional. According to the directional arrows on this model, information needs, seeking, and outcomes create a never-ending loop because outcomes create feedback into the variables that affect it or awareness and sources of information. Information awareness and sources lead into information seeking, which simultaneously produces outcomes and information needs. Thus, role and task are prime motivators to prompt information needs that give rise to the information seeking process, which is cyclical within the greater context of work environments, roles, and tasks. Personal beliefs or attitude are not depicted in this model.

Leckie et al. recognized that information needs are not constants, nor are information-seeking behaviors routinely predictable. They listed intervening factors that influence information needs such as "individual demographics (age, profession, specialization, career stage, geographic location), context (situation specific need, internally or externally prompted), frequency (recurring need or new), predicability (anticipated need or unexpected), importance (degrees of urgency), and complexity (easily resolved or difficult)" (p. 182-183). They listed variables that influence awareness of information such as

> familiarity and prior success (results obtained from strategy or source), trustworthiness (how reliable or helpful), packaging (convenience, usefulness, and others), timeliness (found when needed), cost (relative cost-effectiveness), quality (level of detail, accuracy, and so on), and accessibility (relative ease of access). (p. 185)

Finally, they listed characteristics of information sources such as

> types of channels or formats, including formal (for example, a conference, a journal) or informal (for example, conversation); internal or external (source within organization or outside); oral or written (that is, written including paper copy and electronic text); and personal (won knowledge and experience, professional practices). (p. 185)

Leckie et al. (1996) used an educator at a university in the health profession as an example and reported that these educators may assume a primary role as researcher and two sub roles, service to the public and teaching. As a researcher, tasks involve conducting research, writing publications, and speaking at conferences. As service to the public, tasks involve public presentations; while in a teacher role, tasks involve planning and curriculum development (p. 182). Characteristics of information needs related to demographics would be prime specialization, career stage and faculty rank, number of years in teaching subject specialty. Factors affecting information seeking would include availability of formal or informal, internal or external, oral or written, and personal or professional resource formats associated with the department or greater university setting. Factors affecting awareness of information include the educator's perceptions of past success and failures, accuracy, convenient packaging, timeliness, cost, quality, and source accessibility. Outcomes are the results of the process, and although optimal results occur when information needs are met, the process begins again if needs are not met or new demands warrant (p. 187).

Foster Nonlinear Model of Information-Seeking Behavior

After reviewing LIS literature on how researchers find and use information outside their core disciplines, Foster (2004) concluded that understanding the information behavior of interdisciplinary scholars had been neglected (p. 229). Foster proposed a new model, based on his naturalistic inquiry with grounded theory analysis, that addressed information behavior in the context of interdisciplinarity. He suggested his model "showed information-seeking to be nonlinear, dynamic, holistic, and flowing," and he criticized models, theories, and perspectives by Dervin (1983), Wilson (1997a), Leckie et al. (1996), and Kuhlthau (1994), among others, for their linear process stages and iterative activities (p. 228).

Foster's (2004) model illustrates three core processes and three levels of contextual interaction, for a total of many combinations of 6 components. Nested in the center are core processes, *opening, orientation*, and *consolidation*, with unidirectional arrows from one to the other (p. 232). Encircling these core processes are three levels of contextual interaction with intervening factors, *cognitive approach*, *internal context*, and *external context*. Each of the six components will be detailed and a representation of the model is shown in Figure 7.

Foster (2004) acknowledged that information behavior was not isolated from the work environment of the information seeker, which he deemed external context. These barriers and influences on information behavior included categories of Social and Organizational, Time, the Project, Navigation Issues, and Access to Sources (p. 232). By Social and Organizational, Foster meant networking aspects that he believed were vital to interdisciplinary scholars and involved social "goodwill networks between

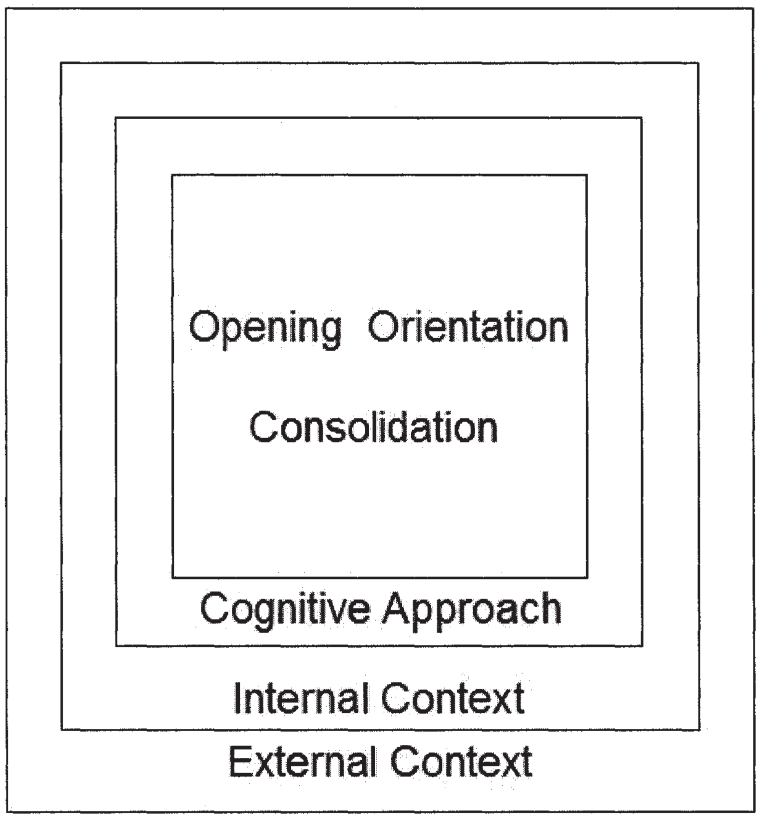

Figure 7. Nonlinear Model for Information-Seeking Behavior. Although Foster identified the opening, orientation, and consolidation to information seeking as core processes, he placed no directional arrows to indicate linearity. The contextual factors surround the core processes. Adapted from Foster (2004, p. 232).

individuals from a variety of backgrounds, status, and disciplinary origins collaborating to share information" (p. 232). Time and the Project recognized the information-seeking problem or project and limiting or open ended factors of time or resources needed to solve the problem (p. 232). Navigation Issues and Access to Sources refer to the organization of information and problems this presents to interdisciplinary researchers as they move from their home discipline (p. 232).

A second level of contextual interaction with the core processes was internal context. These internal barriers and influences include Feelings and Thoughts, Coherence, and Knowledge and Understanding (Foster, 2004, p. 233). Foster suggested the internal influences are the "level of experience and prior knowledge held by the information seeker" (p. 233). He listed internal feelings of uncertainty, self-efficacy, and complexity, as well as internal Knowledge and Understanding of experience, information need, and knowledge level (p. 233).

The third level of contextual interaction was the cognitive approach, or the barriers and influences related to the mode of thinking and willingness to use information (Foster, 2004, p. 233). Foster identified four Cognitive Approaches of Flexible and Adaptable, Openness, Nomadic Thought, and Holistic approaches. The Flexible and Adaptable approach represents "mental agility and willingness to adapt to different information," while Openness is an open-minded approach, for example with "no prior framework for judging relevance . . . all sources, disciplines and ideas are viewed as viable until proven otherwise" (p. 233). Nomadic Thought "embraces the process of thinking about a topic in many diverse ways to find the information needed in locations and ways remote from the original idea" (p. 233). Holistic Approach incorporates concepts from answer or to generate new questions (p. 233).

Foster (2004) explained that his Opening concept, one of the core processes, bore similarity to first steps in other information-seeking behavior models such as Ellis from 1989 and Kuhlthau from 1994 (p. 233); however, he insisted his Opening differed in that it was a collection of activities that corresponded to moving from a state of orientation to seeking, exploring and revealing information" (p. 233). Activities included in the Opening are Breadth Exploration or conscious expansion of searching, Eclecticism or accepting, gathering and storing information from diverse range of sources, Networking or main activity for locating information and sources operated through conference, social gatherings, colleagues, departmental research groups, Internet, E-mail, Mailbase groups, Keyword Searching or use of databases, online catalogs, Internet search engines, online journals, Browsing or accessing information by scanning sources, Monitoring or repeated visits, Chaining or citation and reference connections, and Serendipity or luck or coincidence (p. 233).

Another core process for Foster (2004) was “Orientation” or the "diverse range of activities covering the identification of existing research, key themes, disciplinary communities, latest opinion, sources, keywords, and picture building" (p. 234). Activities included in Orientation are Problem Definition or repeatedly redefining the focus and boundaries of problems, Picture Building or set of behaviors to map relevant topics, Reviewing or use of intrapersonal sources to develop a baseline from which to develop new information needs, Identify Keywords or finding suitable terms, Identify the Shape of Existing Research or identifying key names, articles and opinions (p. 234).

The final core process was Consolidation, which Foster (2004) said "looped and intertwined with Orientation and Opening" (p. 234). Activities included in Consolidation are Knowing Enough or reiterative process of questioning whether sufficient material was acquired, Refining or setting boundaries and narrowing focus, Sifting or deciding relevance, Incorporation or information organization through thinking, writing, discussing with colleagues, Verifying or need accuracy judgment of materials, and Finishing or "sweeping up loose ends before closure" (p. 234).

Foster (2004) concluded by stating four major implications of his new model. First, the model is an alternative to tradition models with sequential stages, and it has no problem solving framework (p. 235). Foster suggested his model was a slice of a temporal continuum, and he stressed that information behavior among interdisciplinary scholars was "cumulative, reiterative, holistic, and context-bound" (p. 235). Second, the model is an alternative explanatory framework that addresses anomalous patterns of behavior and missed stages (p. 235). Third, the model provides a framework to teach information literacy and library skills that reflect actual behaviors (p. 235). Fourth, the model suggests that layers of activities are located within a context (p. 235).

Summary

Vakkari (1997) stated that information needs and seeking are no longer studied as "ends in themselves, but they are seen as embedded in the actions, tasks and situations they are supporting" (p. 457). He went on to say information is only one dimension of task completion, and the associated information needs and seeking are subordinate to the action or task to be fulfilled (p. 457). As such, studies begin with analysis of the task followed by a focus on information behaviors connected to task completion, and Vakkari called this an action-centered perspective (p. 457).

To test existing models of information needs and behaviors on geoscience educators in their tasks, actions, and situations of course development and instruction is not the intent of this research. However, Wilson (1999) pointed out models of information behaviors are frameworks for thinking about the problem and relationships (p. 250). Wilson (1997b) contended that a general model must include "the factors that give rise to an individual's perception of a need; the factors that affect the individual's response to the perception of a need; and the processes and actions involved in that response" (p. 39). This grounded theory study will address Wilson's suggestions, as well as Vakkari's task, action, and situation in later chapters.

CHAPTER 3

RELATED RESEARCH

Identifying information needs and behaviors of geoscience educators in academia can bring new insights to academic library practitioners and educators. Librarians act as liaisons to educators and design services to meet information needs. Likewise, educators act as liaisons to students, potential practitioners, and design courses to meet subject specialty information needs. It may be inaccurate for librarians and educators to simply assume the same methods of providing and transmitting information needed to support a person's research will suffice for teaching. In order to explore information uses and users, this research examines perceived needs and subsequent behaviors of geoscience educators when developing and planning curriculum and instruction for introductory geoscience courses in a university setting.

Geoscience specialty librarians have published annual proceedings of the Geoscience Information Society (GSIS) about geoscience resources, information usage, and geoscientists within their local library settings, since 1969. In addition to subject specialty practitioners and Bichteler Hallmark, an LIS educator, little information has been published on a community of geoscientists, while many practitioners and LIS educators have published on some greater community of scientists and engineers (Seggren, 1995). Whether these micro and macro findings can be used to model information use and user in developing and planning curriculum and instruction can only be determined by studying geoscience educators and the way they make sense of their teaching roles. Thus, this research is person-centered, and data are gathered from the geoscience educator's viewpoint. Dervin's (1992) model of the sense-making process has a person-oriented focus and provides a functional framework for analyzing how educators operate in a teaching role to define information needs for curriculum and instruction. Dervin's sense-making model is premised in constructivism, and this approach and perspective support her belief that a problematic situation is not always satisfied with objective information found in formal information sources or the functional units of information common to academic libraries. Thus, sense-making and constructivism provide the direction to examine how people develop the knowledge base of a discipline and what types of information sources and methods people use to facilitate learning in the geoscience disciplinary knowledge base.

In addition to Dervin's (1992) sense-making, other areas of library and information science literature inform this study. This research involved not only the role of information needs in educational activities, but also information behaviors or the methods employed to seek and gather information. As such, literature on information needs and behaviors from the user's viewpoint has special relevance. However, most reports from geoscience educators on what information they need, where they found it, and how they use it, are not in LIS literature rather in science and geoscience education literature. Case (2002) noted only two LIS studies specific to geoscientists' information needs and seeking behaviors from a person-centered orientation (p. 233, 235), and these were in 1976 and 1989, prior to commonplace electronic information communication. Also, Derksen and O'Donnell (1995) noted how few inventoried topics covered in the GSIS proceeding papers were specific to instruction and education (p. 5). Finally, it is ironic that Musser (1993) found literature of the GSIS proceedings, the main source of library studies on geoscience use and user, were poorly covered in traditional library literature indexing and abstracting sources such as Library Literature, Library and Information Science Abstracts, and Information Science Abstracts, and well covered in an a comprehensive geoscience indexing and abstracting source, GeoRef (p. 77). This implies that there is a gap in the LIS literature on the information needs and behaviors of geoscience educators from their viewpoint and indeed, this research may contribute to a better understanding in library and information science of this under served community of scholars.

Although there is LIS research on the use of information collections, systems, services, and facilities among scientists and engineers, this does little to contribute to neither identifying information needs, nor examining preferences and concerns for information resources wanted in developing and implementing course and instruction. Models inclusive of information needs and recent research models on information seeking among professionals and interdisciplinary scholars may contribute to understanding an educator's information behaviors. Applications of these models will be reviewed to shed light on information needs and information behaviors in context.

Sense-making in Contexts

T. D. Wilson (1999) insisted Dervin's sense-making was a model of methodology (p. 257). He asserted the strength of her sense-making illustration is in methodological consequences or the way questioning can reveal the nature of problematic situations, the extent to which information serves to bridge a gap of uncertainty or confusion, and the nature of the outcomes or uses to which information is put (p. 253). Dervin (1999) calls this situation-gap-outcome triangle of sense-making a "theory of method and method of theory" (p. 748). As a method, Dervin (1992) calls sense-making an approach to study perceived needs, i.e., what they want, what they receive, and what they think about it (p. 61). As a theory, the premise is that sense making is "an inherent intertwined connection between how you look at a situation and what sense of it you are able to construct" (p. 39). Thus, sense-making as theory and methodology enable geoscientists to understand geoscience concepts and facilitate student learning. Force (2000) provides an overview of how geoscientists look at problematic situations in nature and construct meaning through fieldwork, which is needed to gain a better understanding of geoscientists and their learner-centered approach.

Sense-making and Geoscientists

Force (2000) devoted his dissertation in the discipline of education to examining a community of geoscientists and exploring the "evolution of what counts as knowledge" and the "nature of knowing, knowledge, and reality" in the geosciences (p. 8). He was a participant-observer among geoscientists on a geological field trip led by two professors for the purpose of examining rocks and fossils in situ. Force described his thesis as an "inquiry into the nature of sensemaking" or how the events of the field trip were shared experiences that influenced "the participants in their efforts to develop shared understandings of various natural phenomena" (p. 1). He was not concerned with knowledge claims, rather the processes that contributed to the development of geoscience knowledge claims (p. 1).

Force (2000) adopted Weick's (1995) explanation of sensemaking as "the act of making a situation sensible" with a focus on process over product (p. 2), which is similar to Dervin's sense-making. Force simply stated, "sensemaking is what people do to construct the reality of the world in which they live" (p. 2). Force contended the function of the geoscience field trip was to provide personal and direct experiences to a group of educators and students; however, these personal experiences involved interaction among people who shaped "each other's meanings and sensemaking (interpretations and interpretings) through joint actions" (p. 3-4). Although Weick's sensemaking has an overall organization-oriented focus steeped in social constructionism, this researcher will consider it complementary to Dervin's sense-making, which is a process theory and methodology steeped in constructivism.

Force (2000) concluded that geoscience is a way of knowing in which people make meaning through *being there*, *storytelling*, and *living together* (p. 149). *Being there* is a metaphor for the direct interaction of geoscientists with the physical world, while *storytelling* is giving meaning to these direct experiences and building a sense of community among geoscientists through discussion (p. 149). *Living together* is metaphorical of a community of geoscientists who develop and maintain a shared knowledge base, which defines a discipline through confirmation or rejection of information gained from *being there* and *storytelling* (p. 149). In other words, *being there* identifies Dervin's *nature of a problematic situation*, while *storytelling* is a way of *bridging a gap of uncertainty and confusion*. Finally, *living together* is the *outcome and use* to which information is put. Personal accounts revealed some specific information about geoscience and geoscientist.

Being There

Sense-making by *being there* means going beyond laboratory, classroom, and text-based experiences to the direct encounters with rocks and fossils in the context of the natural environment (Force, 2000, p. 150). For example, one participant in Force's study simply said, “being there" gives you a "better feel for it" (p. 125). Several people suggested that for a paleontologist, seeing a historic fossil site was a *pilgrimage* and "until you have done it, until you've been there, you don't realize how isolated the thing is" (p. 125). Although some participants were familiar with specimens taken from one site and housed in a museum and others had extensive reading knowledge about these fossils and sites, many agreed that "the only way to learn paleontology was by being out in the field" (p. 102). One participant said, "You certainly remember the things you see, feel, and touch" (p. 152). Artifacts from the field, whether photographs or specimens, are valuable to remind one of a field experience; as one person explained, "rock or fossil specimens can also serve as a focus of contemplation for understanding the geological processes associated with the particular sample collected during a field experience" (p. 157). Although text can give background, a participant noted field experiences provide context, and context is the missing element in journal articles, conference presentations, and the like (p. 156).

Force (2000) noted the field trip leaders kept formal lectures in the field to a minimum so others could contribute to discussion with questions or comments regarding similar formations they had seen elsewhere (p. 153). This emphasizes the "notion that knowledge is not simply out there in the external physical world" (p. 153). Participants recognized that although everyone was looking at the same thing in the field, each looked at it differently depending on their backgrounds (p. 154). One person mentioned he came into paleontology via biology and approaches problems differently than geology-based paleontologists (p. 112). Another participant suggested that paleontology benefits from making connections between fossils and living organisms (p.124). Making connections and looking at a problematic situation from different viewpoints was deemed important, and a participant said, "a field experience is by far the best learning experience or the chance for you to jump to a different level" (p. 155).

One participant "spoke out against the idea of scientists knowing absolute truth" and said, "what we know today will in six years be as wrong as what we knew six years ago" (Force, 2000, p. 108). A participant went on to say, present truth is based on present scientific information; if the assumption is wrong, the solution is wrong, but if the assumption is right, the solution is acceptable at that time (p. 115). Plate tectonics was cited as an example of a major shift in thinking about and understanding geology (p. 111). Although "all agreed that what is considered truth today may not be considered truth in the future" (p. 115), one participant observed that "the general public views science as more truth-based than do the scientists themselves" (p.112).

It was noted during the field trip that "the best geologist is the one who has seen the most rocks" (p. 159). Through his experiences, Force concluded *being there* was a distinguishable pattern of sense making activities that were ongoing, enactive, focused on extracted cues, social, and retrospective for these geoscientists (p. 159).

Storytelling

Force (2000) believed "storytelling concentrates on giving meaning to direct experiences of the field trip as well as on building a sense of community from which confirmation or rejection is given" (p. 149). Examples of storytelling as sense-making came with discussion that accompanied stops of the field trip. The geoscientists would begin a sentence with, "as far as we can tell" or "it's been suggested that," and continue with shared stories about past and present geologists and life in general (p. 161). Participants equated geology with detective work and after clues lead to a solution, a paper is presented to the geoscience community for affirmation or rejection (p. 164).

"The elegance of a story is more important than the reality," one participant said and continued that historical geologists are "gossipers" (Force, 2000, p. 166). Another participant commented that stories of field adventurers are an escape from normal life and ordinary jobs (p. 168). Stories clarify meanings in that, "knowledge is dependent upon the knowledge maker" and it is not about what geologists see, rather how they interpret what they see based on previous experiences (p. 166).

Force (2000) found that to enhance and validate storytelling, geoscientists recorded their direct experiences through photography and included something to show the scale in each picture, whether it was a person, coin, or other (p. 110). Besides this alternative to collecting specimens in the field (p. 111), photography served as a way to share the experience with others or retell it. One participant set up a tripod and took pictures every 18 degrees through a full circle; he said the resulting images would be scanned and processed with a computer program to create a panorama and made available to museum viewers to experience the landscape as if they were there in the field (p. 122). Thus, with photography, specimen collection, or both, participants spoke of doing educational outreach with university classes and conferences or local high school students (p. 126). One educator reported the importance of her being on the trip was "in telling her students about it, she would be able to go beyond what she had read and talk about what it was really like up there" (p. 124-5). Through his participant observations and subsequent interpretations, Force demonstrated *storytelling* as another distinguishable pattern of sense making activities.

Living Together

The cultural and social world was a part of sense making during the field trip through ongoing interaction with the geoscience culture of the physical world and with each other. Individual *knowing* and community *knowing* co-evolved during the trip which Force saw as both a scientific and social event (Force, 2000, p. 172). One participant commented that geoscientists can be completely immersed in field talk, freely criticizing other's views without showing negativity toward the people as scientists (p. 174-175). Force noted the extended time together that a field trip provides, allowed participants to develop a trust level, which was not achievable in other professional contexts (p. 175).

Relationships can develop through living together as well as an open exchange of scientific information or data (Force, 2000, p. 180). One professor related the story of having German students in class who were shocked that Canadian students would argue with their professors; the professor telling the story said it was okay to question ideas because it was "part of learning how to make an argument and to defend one's position as well as change another person's thinking" (p. 131). The professor continued, saying that argument challenges both teacher and student to think in different ways and if you make a decision and never revise it, then it stagnates (p. 131). One participant related his own experience, that he looked at opposing sides of some ideas argued about in the literature for over twenty years (p. 131); approaching the problem from another direction allowed him to design a new model to incorporate all observations (p. 132).

In Force's (2000) case study, the field trip was a pre-conference excursion and participants went on to an international geoscience meeting. Through reflecting on the entire event, these participants explained benefits of different means of geoscience communication. In discussing the value of professional conferences, participants agreed that meetings provided opportunities for networking with others working on similar projects and an avenue for graduate student placing and job searching (Force, 2000, p. 117). In addition, getting to know personalities first hand or through *gossip* was important; one person said he reads papers or attends a talk with a filter which is both positive and negative because he can "know the name now and associate it with a face and a personality" (p. 181). Thus, *living together* means providing people with a shared experience of a physical and social world, which fostered the *storytelling* of *being there*, and created a sensemaking process both during and after the field trip event (p. 182). For Force, being there was the raw experience and sense was made through formal and informal interviews and discussions; without the living together experience there would be no stories to give meaning to the formal, objective data (p. 184). Force demonstrated this through his dissertation research and for geoscientists as well.

Constructivism in Contexts

Just as sense-making provides a theoretical and conceptual framework for understanding information needs and implementing action by subsequent information behaviors through the work of Dervin (1992) and Force (2000), constructivism further develops this lens for viewing information behavior among geoscience educators. For this research, constructivism is a theory for understanding the nature of cognition or how people learn. For geoscientists as constructivists, learning is built on the premise that personal understandings are constructed by reflecting on personal experiences and interaction with a physical and social world. Learning becomes a process of extending or adjusting existing knowledge to accommodate new information into an individual's schema. In a likewise manner, constructivism not only frames a geoscientist's learning process but also a student's learning process and thus, constructivism shall frame a geoscientist's learning-centered approach to instruction. Finally, constructivism is evident in a library and information science context as well. Literature in both theory and practice will be reviewed for LIS and geoscience education.

Constructivism in Library and Information Science Education

Constructivism is a communication process theory, which defines the constructive process of learning through communicating, not through transmitting information. As such, in a library and information science context, Kuhlthau (1994) used constructivism as a foundation for explaining information searching and mediating in a library setting based on the uncertainty principle. Kuhlthau's (1994) research focus has been to redefine traditional library services from a "bibliographic paradigm to users' problems and process" (p. xxv) and from traditional librarians' roles of collection organizer to mediating counselors who address information needs and create process instruction (p. 147).

Savolainen (1993) suggested that research that adopted a user-centered approach to the conceptualization of information seeking and use based on constructivist assumptions, has *opened our eye* to limitations of empirical research posited on a positivistic philosophical paradigm or worldview (p. 27). Research by Dervin and Kuhlthau has not gone unnoticed; however, the majority of the LIS research focus is slow to change and continues to be concerned with, for example, counting and measuring people's use of information collections and facilities, as well as their nonuse of abstracting and indexing databases. For geoscience examples see Derksen and O'Donnell (1995).

The use of information *versus* information user focus was recently highlighted by White (2003) when he identified 121 of the most highly-cited information scientists in literature from 1972 through 1995 applying a co-citation analysis (p. 428). Author's literature contributions created specialty categories and the following break-down: <1% communication theory, 5% user theory, 5% imported ideas, 7% scientific communication, and the remainder, 82%, represented by experimental retrieval, citation analysis, bibliometrics, online retrieval, online public access catalogs, library systems, and indexing theory (p. 428). Thus, of the most highly cited information scientists, Dervin and Kuhlthau included, 18% are conducting "person-centered" research, while 82% are engaged in "systems-centered" research or as Savolainen (1993) calls it, user-centered *versus* "traditional intermediary-centered" (p. 13). In contrast with the majority of researchers in LIS, Kuhlthau created convincing evidence for considering thoughts, feelings, and actions within information behavior of information users and mediators, whether they are librarian or geoscience educators.

The Uncertainty Principle

The uncertainty principle for information seeking resulted from recognizing that the information seeking and use process was constructive and that peoples' cognitive-thoughts, affective-feelings, and physical-actions must be considered. An early stage of information seeking, or Dervin's problematic situation, is accompanied by uncertainty and confusion and thus, an uncertainty principle is the underlying conceptual framework for the information seeking process. Uncertainty is due to a lack of understanding and bridging the gap of uncertainty for Kuhlthau (1994) could be explained with six corollaries, process, formulation, redundancy, mood, prediction, and interest (p. 125-126). *Process* is constructive, influenced by prior knowledge and time (p. 111). *Formulation* is focusing and thinking, influenced by mediation (p. 113). *Redundancy,* influenced by mediation, is encountering expected and unexpected results; expected results are judged for relevance, while unexpected results require reconstructing schemata to be judged as useful (p. 117). Tangible results could be seen as the quantity and quality of resources and as uncertainty decreases, redundancy increases; and likewise, a lack of redundancy may be an underlying cause of uncertainty (p. 116). *Mood* relates to attitude and in a linear progression, if redundancy is low, then a negative or closed attitude may hinder the next step in a search (p. 118). *Prediction* is based on expectations derived from past experiences (p. 121), and with increasing intellectual engagement, *interest* increases and uncertainty decreases (p. 122). Although an individual's cognition affects uncertainty, problematic external systems and services intervene in success or failure in the search.

Kuhlthau (1994) called the uncertainty principle and its six corollaries the theoretical view of looking for information or a holistic view of the information search and searcher (p. 127). Both Kuhlthau's ISP and Levels of Mediation and Education are framed by the uncertainty principle within the three levels of thoughts, feelings, and actions. This process and practice "provides a framework for assessing existing instruction and developing new levels of education," and Kuhlthau goes on to state, "education that guides students through stages of information need, to solve a problem or to shape a topic, enables them to use information for learning" (p. 154).

The Information Search Process

The six stages in the Kuhlthau (1994) model for looking for information are task initiation, topic selection, prefocus exploration, focus formulation, information collection, and search closure or presentation (p. 42-49). Initiation is recognizing a gap in knowledge, while selection is identifying the topic of investigation. Exploration is forming the focus and locating relevant information based on what an awareness and availability of information sources. Formulation is a turning point and a focused perspective results if successful. Collection is gathering information and presentation is the closure of the search and resolution of the initial gap in knowledge.

Kuhlthau (1994) recognized information seeking as a primary activity people use to deepen their understandings of the world and identified libraries as premier environments conducive to information seeking (p. 14). Kuhlthau developed the ISP model to help both student and mediator to "facilitate understanding, problem solving, and decision making" through improved instruction and reference services (p. 188).

Service and Information Mediation

"The constructive process of learning in the library requires services which enable individuals to relate new information to what they already know and extend that knowing to form new understandings" (Kuhlthau, 1994, p. 4-5). Kuhlthau believed librarians should recognize the need for life-long learning in an information-rich environment and when considering the user's perspective, the focus of the library changes from providing resources to providing instruction (p. 187). Within a library setting, Kuhlthau recognized five levels of instruction styles including organizer, lecturer, instructor, tutor, and counselor (p. 147). Organizer maintains a self-service approach and assumes the student or library user is a self-teacher or self-reliant (p. 148). Lecturer provides a general section or orienting instruction, usually with large groups and no specific problem in mind (p. 148). Instructor gives help with a single issue or problem, such as explaining a concept or identifying a relevant source (p. 149). Tutor sustains a series of sessions with strategies to locate and use sources for a specific problem or assignment (p. 150). Finally, the most involvement between student and mediator is at Kuhlthau's counselor level, where process instruction is aids with identification, interpretation, and evolution of a problem (p. 151). At this level, mediation and education merge into an interactive service (p. 151).

Some library educators and librarians have heeded Kuhlthau's challenge for increasing instructional services and assuming a greater pedagogical role in the academic environment. Owusu-Ansah (2001) called for a change from a marginal teaching role for academic librarians to university formal recognition of library instruction for general education requirements (p. 282). As is commonplace now, Leckie and Fullerton (1999) suggested that academic librarians and other faculty do not understand each other's roles or expectations; they illustrated this point by contrasting a variety of dominant pedagogical discourses held by librarians with ones held by other faculty (p. 1). For example, some educators believe as scholars in their discipline, only they know and deliver the concepts that must be taught; in contrast, some librarians, as service providers, do not assume the structure of a discipline defines what must be and equate their position with asking other faculty what they need (p. 4-5). Leckie and

Fullerton suggested that librarians reflect upon pedagogical discourse and adopt useful pedagogical roles such as liaison, collaborator, mentor, and supporter (p. 7-8). Complementary roles may mean providing access and awareness of formal resources for an educator interested in transmitting information to the student, while facilitating access and awareness of alternative sources for an educator with a constructivist approach to student learning.

Riddle (2003) suggested that service learning offered opportunities for a library class that would improve information literacy. He described service learning as a triangulation of community engagement, learning, and reflection, and attributed this technique to Dewey's (1938) *Experience and education* and Kolb's (1984) *Experiential learning: Experience as the source of learning and development* (p. 72). One example of service learning given was a class co-taught by English and library faculty members in which students were responsible for writing on-line user guides for the library catalog and databases (p. 76). These students helped fellow students understand and use on-line library resources effectively and they helped themselves become better at navigating information systems (p. 77). Riddle wrote that the value of "service learning provides librarians opportunities to think outside the information literacy box" and that engagement with faculty and their pedagogy, as well as with the broader community of campus and non-campus issues, could enhance the role of the librarian and their degree of relevancy in higher education (p. 77-78).

Other examples of librarian instructional services are liaison and collaborative projects. Yang (2000) reviewed library liaison programs that were designed to connect academic librarians to academic departments. Although the aim for librarians was to facilitate communication and increase "awareness of faculty needs for teaching and research" (p. 124), Yang found most faculty were either completely unaware of the program or uninformed on its objectives (p. 128). "The liaison librarian was not typically viewed by the faculty as a research consultant, but rather as the first person they contact when they experience others problems with the library" (p. 128).

Manuel, Molloy, and Beck (2003) reviewed of the literature regarding faculty use and nonuse of library instruction and proposed collaborative projects as a way to improve services. They researched faculty attitudes and found students' library use was shaped by professors' expectations; if professors promoted and utilized library-provided instruction, students would do likewise and research skills showed improvement. Unfortunately, Manuel et al. found the majority of faculty does not utilize library instruction and they urged academic librarians to find ways to collaborate with educators. Also, they observed that while faculty was committed to teaching, Manuel et al. believed some educators lacked the interpersonal skills needed to develop collaborative activities outside of their specialties (p. 137). Non-librarian faculty research was often narrowly defined and this disciplinarity worked against collaboration because: (a) non-librarian faculty viewed librarians as lacking a discipline and thus "lesser players in higher education;" (b) non-librarian faculty were more interested in the results for content specific instruction and less interested in library instruction promoting information search skills (p. 137). Despite their disappointing findings, Manuel et al. believed their research had implications for selling library services to faculty and identifying potential faculty for collaboration (p. 131).

Each of these research reports is an example of librarians in mediating and instructional roles based on constructivist and sense-making processes which can enhance a client's information seeking and use. From the geoscience educator's perspective, this mediation could be useful to support their teaching and enhance their students' learning. The literature from education will be reviewed for examples of constructivist and sense-making applications in general and specific to geoscience courses and library-geoscience mediation situations.

Constructivism in Science Education

Fosnot (1993) defined learning "as a self-regulated process of resolving inner cognitive conflicts that often become apparent through concrete experience, collaborative discourse, and reflection" (p. vii). She believed the learner was an active agent who constructs knowledge and meaning individually and socially. Fosnot went on to define knowledge as "temporary, developmental, socially and culturally mediated, and thus, non-objective" (p. vii). Although few would argue with her view of the constructivist learner, Fosnot's definition for knowledge as non-objective has kept constructivism from universal acceptance in science. Taken to an extreme, if there is no knowledge independent of the meaning attributed to the experience by the learner or community of learners, then there is no fixed external reality and constructivism becomes a relativistic epistemology.

Constructivism as a relativistic epistemology means *all* knowledge is considered to be *about* the world, not constitutive of the world. Although Bruner (1986) warned that constructivism need not endorse radical relativism (p. 98), Osborne (1996) and others have taken exception to this aspect of constructivism and defended the rational, realistic epistemology of what is called "normal science" (p. 76). Osborne criticized researchers (e.g., Latour & Woolgar, 1986) who generalized results of their studies of scientists working at the fringe or frontiers of science understanding and portraying this activity as "normal" science (p. 73). He said that scientists do not dispute that knowledge is a human construction; however, there is a firm belief in the shared truth that distinguishes scientific knowledge from other forms of knowledge and opinion (p. 56). In other words, scientists assume a rational, realistic stance because objects of nature are classified by scientists, independent of the learner and thus, the language of science is "*bound* by reality" (p. 58).

Osborne's (1996) writing concurs with what Cole (1992) argued at an earlier time. Cole criticized specialists in history, philosophy, and sociology for interpretations, such as (a) "science is not a rule-governed activity," (b) "scientific disputes frequently cannot be resolved by empirical evidence," and (c)" science is framed by a relativist philosophical position" (p. 5). Cole identified himself as a realist-constructivist, who "believes that science is socially constructed both in the laboratory and in the wider community, but that this construction is influenced or constrained to a greater or lesser extent by input from the empirical world" (p. x).

Dutch (1996) is also opposed to equating scientific knowledge and relativism; he criticized this as merely "faulty models of science" (p. 248). Dutch believed relativistic claims in science contribute to the success of pseudoscientists, who are "masters of counterfeiting the appearance of science" (p. 249). He argued that the "malaise" in science or the general "anti-scientific and anti-intellectual" movement and subsequent growth of pseudoscience can be attributed to social trends outside education

(p. 245-249). One contributing social aspect of an anti-science stance was also noted by Dewey (1956) in 1902 as the "city-bred child of today" (p. 12). That is, Dewey and Dutch (p. 247) believed increasing urbanization creates a loss of contact between people and nature; when nature is experienced secondhand, students are less likely to understand it and see relevance in science classes because they have no personal constructs with which to relate. Dewey pointed out in 1910, that when science is presented as subject-matter outside the learner and without application, it is merely the transmission of objective knowledge communicated by rote memorization (p. 145-156). Dutch concluded that "problems *in* science education are not the fault *of* science education" and that "there is no guarantee that our society will always be scientific . . . the Islamic world fostered science and learning for centuries before succumbing to anti-intellectual forces" (p. 250).

Phillips (1995) pointed out that simply the variety of types and multiple interpretations of constructivism have caused confusion and resulted in the "good, bad, and ugly faces of constructivism" (p. 5). Disaffirming constructivism in science wholesale has negative consequences though. Gallagher (2000) was disappointed to note that, "a look into most classrooms where science is taught at school or university will show that memorization, not understanding, is the prominent operational goal" and a closer look reveals that teaching applications of science knowledge is nonexistent (p. 2). Shapiro (1994) wrote that an interest in science as a career is low in the U.S., "fewer than 10% of pre-college students profess a genuine interest in science, with only approximately a quarter of these students actually going on to pursue careers as professional scientists" (p. xvi). In spite of resistance to constructivism, there are examples within the sciences of its usefulness.

Osborne (1996) believed constructivism rightly affirms that people are responsible for their own learning and active participants in the learning process, and he noted that the strength of constructivism utilized by science education has been a greater awareness and understanding of the obstacles to learning science (p. 53). Additionally, constructivist's research has shown a positive shift in describing student error from "mistake" to "misconception;" this language shift changed teacher and curriculum developer perceptions of learners as . . . "irrational and unknowing to cognizant beings who have well-developed theories" (p. 63). Osborne recognized that constructivist-inspired educational delivery was a positive development and has shifted teaching from a transmission of knowledge to a process of mediation (p. 63).

Shapiro (1994) viewed the constructivist perspective to teaching and learning in science education as essential in understanding what the learner brings to learning (p. xiv). "The constructivist perspective emphasizes the active agency of the learner, asserting that each learner builds or constructs his or her reality . . . it suggests how educators might enhance that agency" (Shapiro, 1994, p. xiv). Thus, Shapiro believed this perspective was not only a focus on the learner, but the learning and teaching dialogue that includes the role of learner-teacher and organization of curriculum materials (p. xiv).

Thus, proponents suggest that constructivism helps to explain human cognition and as such, this perspective can inform professionals on ways to foster literate individuals through teaching. Constructivism has been utilized and applied in libraries and the sciences as a mode for learning and teaching content and process. In the geosciences, constructivism has been utilized and applied and service and collaborative activities used as tools for teaching and learning will be reviewed as examples of the learner-centered paradigm that exemplifies constructivist tenets as reported in one of the main peer-reviewed journals for geoscience education.

Constructivism in Geoscience Education

Several innovative modes of instruction are practiced within the geosciences in university settings, and these activities are the tools for learning and teaching with a constructivist perspective. The promotion of constructivism through cooperative and collaborative activities and service learning projects are attempts to, as geoscience educators MacDonald and Bykerk-Kauffman (1995) stated, "shift away from classes dominated by lectures and toward classes in which students work together to actively construct, explore, and apply course material" (p. 305). Cooperative learning "is structured so that group members need each other to succeed and are individually accountable for understanding the material" (p. 305). Although Cuseo (1992) categorized cooperative learning as a type of collaborative learning, MacDonald and Bykerk-Kauffman explained collaborative learning as students . . . "working interdependently, but shifts classroom authority from the teacher to student groups" (p. 305). Service learning directs course activities toward real-life problems, usually of a local community concern.

Numerous examples of learning-centered activities with constructivist perspectives in the geosciences come from the geoscience education literature including

Benison (2000), Dowse (2000), Mattox (2000), Reynolds and Semken (2000), and Stull (2000). Some examples that enhance course development and instruction follow.

Mogk and King (1995) introduced service learning into a geology class to provide students with meaningful instruction and to demonstrate to their community that higher education was relevant as process and product that created responsible informed citizens. The course, "Resource and Environmental Geology," adopted a class project to create a public forum on seismic hazards in an earthquake-prone region. Mogk and King reported positive outcomes to students as improving writing and speaking communication skills, research skills, and interpersonal skills, as well as learning science content (p. 464). Also, the students learned the importance of communicating their major course of study, the geosciences, to communities and participating as a "good citizen" (p. 464). According to Mogk and King, the success of service learning depends upon . . . "clear articulation of community needs orientation and training of students, meaningful action, and reflection upon and evaluation of the activity" (p. 461). "Service learning transforms students from passive clients and consumers of information into active agents of assistance to our communities, the nation, and the world" (p. 465).

A second example of constructivism in the geosciences was in creating a deeper understanding of geoscience principles through field observations. Brown, Kelso, and Rexroad (2001) stated "scientific literacy for all Americans continues to be illusive . . . and the number of students pursuing advanced studies in science does not meet industry or teaching demands (p. 450). Therefore, they designed a higher education experience that demonstrated to elementary education majors in a pre-service teaching role both process and content in the geosciences. The pre-teachers experienced active-learning strategies in the context of how science is practiced by going out in the field, with both pre- and post-experience sessions in the classroom. Information, conceptual frameworks, and appropriate process skills were introduced in the classroom; this was followed by a geologic field trip outside of the classroom, and post-lesson information to aid in student understandings and clear misconceptions (p. 451). Thus, this curriculum valued individual, personally constructed understanding of core geologic concepts and problem solving skills over "passive learning formats that emphasize transmission of discrete facts" (p. 450).

Schloman and Feldmann (1993) developed a collaborative bibliographic instruction program for academic educator and librarian to prepare geoscience students to navigate geoscience literature (p. 35). They believed in order to improve information gathering skills, instruction modules should be developed to introduce the structure of the geoscience literature and the process of retrieving and interpreting scientific tertiary, secondary, and primary literature in print and electronic formats (p. 37-40). While Brekke, Brady, and Fisher (1994) took a different approach by investigating geoscientists' use of the GeoRef database, Davis, Brady, and Boehmke (1994) reported their application of teaching students to use such databases. Davis et al. recognized the importance of teaching writing in the geosciences and detailed a cooperative project between geoscience educators and librarians to give introductory geoscience students instruction on the use of the academic library and geoscience literature to improve writing. Davis, a geoscience educator, worked with Brady, a library liaison and collection development librarian for geology, and Boehmke, a reference librarian, to create a project premised on writing as a way of communicating and learning (p. 417). In a review of the literature, they mentioned Bichteler (1985) as an early proponent of introducing higher education students to geoscience literature from the librarian's perspective, and Rickwood (1985), Tinker (1986), Macdonald (1991), and Schneiderman (1991) as proponents of writing in introductory geoscience courses from the geoscience educator's perspective. This joint project demonstrated cooperative efforts between geoscientist and librarian, and they reported on introducing students to an awareness, access, and acquisition of formal geoscience sources, i.e., encyclopedias, books, journals, and indexing databases. Their conclusions regarding the project were two-fold, in that it was an effective model for introducing the library to geoscience students in large enrollment classes, and fewer reference questions were asked by geoscience students in subsequent writing assignments by those who had participated (p. 418). This conclusion measured and counted student's use of library resources and reference librarians, which may or may not have complemented the geoscience educator's pedagogy. Although cooperative learning has merit, this research reported outcomes, not focused on user but rather use of sources. This level of mediation according to Kuhlthau's (1994) scale was as a lecturer or one who provides a general section or orienting instruction, usually with large groups and no specific problem in mind. Although formal geoscience sources were presented, the article did not relate any discussions on gray literature or any reflections on how this collaborative project helped or hindered student learning or educator teaching.

Information Need and Behaviors

Wilson and Walsh (1996) argued that the root of the problem in determining information-seeking behavior is in the concept of information need. They asserted that need is a subjective, individual experience and not directly accessible to the observer or mediator. Consequently, effective models of information needs and behaviors will not merely depict a sequence of events, rather propose relevant contextual or the intervening constructs and interacting actions that act to help and hinder the person's progress to satisfying their information needs. This researcher investigated the geoscience educators' information needs and strategies to satisfy the task of curriculum and instruction and results are given in a later chapter. Past literature describes research that examined information needs and behaviors within a university context and research into the information world of academics follows.

Information World of Academic Scientists and Engineers

At times, scientists and engineers have been considered a homogeneous profession by researchers outside science and engineering. However, Seggren (1995) suggested that "work setting, goals, training, processes, and output of scientists and engineers are different enough that they cannot be lumped together in discussions of communication channels, information needs, and information-seeking behavior" (p. 96). Descriptions of information needs and behaviors of academics, scientists, and engineers will help to distinguish these populations.

Ocholla (1996) studied academics' information needs and information behaviors within a mid-sized public university in Kenya to determine the extent to which faculty in health, education, environmental studies, and information sciences relied upon the library for access to and use of information to satisfy their work-related needs. Ocholla found academic rank influenced information awareness and the nature of the discipline influenced the type of information resource needed (p. 349-350). Academics acquired resources from libraries, but also relied upon colleagues, direct purchase, mass media, archive-record centers, and information-documentation centers, such as the International Council for Research in Agroforestry (p. 353). Among the numerous ways in which academics became aware of the existence of an information source, the journal was mentioned most often, which was followed by casual conversation, common knowledge, article review, and library staff (p. 350-351). Abstracting and indexing services, current awareness services, and electronic document delivery services were not readily available to academics at this "young university" which restricted access and awareness possibilities (p. 351). Ocholla concluded information sources used by academics differed with discipline areas, department goals, and program levels, i.e., undergraduate to graduate (p. 354). He recommended that "the library would benefit academics if equal attention were paid to current awareness services as well as publicity and promotion of information products and services" (p. 345-346).

In a later study covering many South African universities, Ocholla (1999) established that types of resources used differ from discipline to discipline and the nature of the discipline and academic rank are factors in information use and seeking, while academic career development, such as promotion and tenure, drives information needs and behaviors (p. 142). Although university libraries played a "pivotal role in information access by the academics," higher ranked academics, such as full professor with greater experience, exposure, and research productivity, provided a kind of invisible competition for the library (p. 129). This local environment, or both inter- and intra-university information-access networking, was important for levels of academics and Ocholla recommended that avenues to enhance this type of interaction should be supported through the library (p. 119).

Hertzum and Pejtersen (2000) affirmed the importance of inter- and intra-personal information interaction for engineers in Denmark. They noted that colleagues and internal reports are the prime avenues to acquire information, and as they put it, an engineer's information-seeking practices intertwine looking for informed people and informing documents (p. 761). For engineers it is the nature of the design task and their desire to place a final product and process in a specific context that drives inter- and intra-personal information-seeking behaviors. Hertzum and Pejtersen recommended librarians respond by establishing services dedicated to searching for people who author reports in both the formal and informal literature (p. 775).

Soper (1976) researched the *local environment* and explained this as academics using available information from personal publications and personal or office collections, which in part is the result of senior academics' career stage. This was especially true for science disciplines and she found scientists with access to larger institutional libraries had larger personal collections, which included photocopies of library materials; gaps in library collections were not given as reasons for building personal collections (p. 409). Personal collections were convenient to access on demand for academics; the organization of and environment surrounding a personal collection were preferred over the resource arrangement and environment of the library (p. 409). Soper reported respondents accepted the reasons librarians gave for collection organization and regulations and that librarians served many different individuals; however, academics were frustrated by library organization and policy, and thus built local environments which gave them control (p. 410). Departmental or office collections were assembled as well, and although reasoning was similar to building personal libraries, these resources were often designated for the use of students (p. 410). Soper concluded that while books, journal issues, and journal articles comprised the majority of personal collections, materials differed with discipline, and personal resources were heavily used because of the convenience of physical accessibility (p. 414). Convenience and physical accessibility account for the dependence upon inter- and intra-personal sources among academics in South African universities as well (Ocholla, 1999, p. 129).

Quigley, Peck, Rutter, and Williams (2002) were subject specialty academic librarians, who surveyed the science faculty, including geologists, at a large-sized university in the mid-west United States, regarding their information use and seeking behaviors, both preferences and barriers. Researchers found considerable variability among the scientists surveyed with regard to types of resources considered useful. For example, although preprints were deemed useful by 70% of the astronomers, only 13% of the geologists and 9% of the chemists found preprints useful; of the formal literature, such as *Current Contents*, 64% of the chemists found this tool for current awareness useful, while no statistics faculty had ever used this service (p. 5). The results of their forced-choice questionnaire showed respondents checked off browsing journals, attending conferences, and following citation trails as the most useful information resources for keeping current (p. 6). The most useful information resources checked off for managing routine research needs, conducting literature searches, and navigating less familiar areas were searching databases, following reference leads, reading review articles, consulting personal collections and colleagues (p. 6). The questionnaire presented six factors influencing information resource preferences including (a) convenient place and time; (b) time effective to track down; (c) current, up-to-date information; (d) authoritative reliable and complete; (e) familiar, tried and true; (f) reliably available, no wait and no hassles (p. 2). *Most convenient* and *most time effective* were first and second choices marked by educators for keeping current, managing routine research, and navigating less familiar areas, while *most familiar* was the top preference factor in conducting thorough literature searches. "Most authoritative was not selected by any respondents as a factor most influencing their choice of an information resource" and the researchers speculated that this was more important to librarians or others not familiar with the knowledge base of a particular subject area or discipline (p. 7). In addition, the survey asked open-ended questions on barriers encountered and four themes emerged, information retrieval difficulties, time constraints, unavailable sources, and inconvenient physical library location (p. 8). Faculty was unhappy with the lack of electronic access to older literature, gray literature, and foreign literature. Respondents enjoyed aspects of information seeking as well, such as the *thrill of the hunt*, the advanced capabilities of technologies, and the experience of serendipity in unexpected resources and connections (p. 9). Researchers reported that one goal of the survey was to make faculty aware of services and to identify concerns; however, there was nothing to be done about the consolidation of small departmental libraries into a new centralized facility, which was a main concern with this surveyed science faculty (p. 12).

Palmer (1991) argued that although information behavior for scientists and others engaged in research is conditioned by what library and information services are readily available, the prime determinants are the nature of the discipline and work role (p. 124). Specifically, she found information behavior is most affected "by rate of change in the subject, by length of time respondents had been working in the organisation and in research area, and by the extent to which other subjects impinged upon their central research interest" (p. 124-125). Additionally, Palmer's research clearly shows that "users in a single organisation and with common goals, are not an undifferentiated mass; different sectors of the population have different expectations of an information service and require different treatment" (p. 125). After conducting 67 interviews and personality inventories of biochemists, entomologists and statisticians, Palmer created an objective classification scheme of personal information styles on a continuum from active to passive information behaviors, considering both information use and seeking. The most active personal style was *hunter*, who maintained consistent information-gathering routines and were scientists "driven by demands of their subject which all recognised as 'exploding'" (p. 121). Next were *confident collectors*, who did not have regular information-gathering routines yet felt they had adequate access through their activities (p. 120). *Unsettled, self-conscious seekers* were in unfamiliar subject areas and consequently, used the library heavily and had frequent contact with colleagues within and outside the organization (p. 119). A group with information gathering habits that involved scanning several subject fields and relying heavily on intrapersonal knowledge and experience were termed *lone, wide rangers* (p. 118). The most passive personal style was termed *non-seekers* and included mostly statisticians who communicated with other researchers and provided statistical services but never gathered information (p. 117). Palmer created a subject classification scheme as well, based on: (a) the degree to which they sought information, (b) attitudes toward information overload or under load, (c) the need to be in control, (d) the range of searching (p. 123). The categories varied from broadly networked scientists to non information users and were termed information overlords, entrepreneurs, hunters, pragmatists, plodders, and derelicts (p. 123). Although Palmer's results were based on a large sample size, qualitative and quantitative methods, and statistical analysis, not all information user studies are about information users from their direct perspective.

Hart (1997) observed that information needs and behaviors varied with work expectations for teaching and research, the nature of disciplines and resources. He viewed information gathering sources among academics in two dimensions, formal and informal *versus* personal, local, and global sources of information. Formal and global meant information gathering of formal sources from other libraries, while personal and local was collecting formal sources from personal and college libraries. Informal sources could be gathered from personal or department and colleagues, and local or other on-campus colleagues; informal sources could be gathered from off-campus colleagues or attendance at professional meetings. This was a traditional survey study of the use of sources of information, which included faculty in social sciences, humanities, and sciences. Hart suggested that faculty with heavy teaching and service expectations differ from those at research institutions in their information gathering behaviors

(p. 21-22). For instance, Hart reported faculty with active research agendas and publishing demands are more active information-seekers, with larger personal collections and active informal communication networks (p. 21). In contrast, Hart suggested that most faculty at "community colleges, liberal arts colleges, or comprehensive colleges" where undergraduate education is mainstream are active information gathers and make use of personal libraries, as well as local and global; additionally, formal sources are more important than informal (p. 26). Hart found that the use of books and journals varied across disciplines (p. 21). While Hart recognized heavy teaching and service expectations are important contextual factors, the broad generalization on the use of sources in collections does little to inform librarians on specific faculty information needs, behaviors, and concerns.

Maughan (1999) collected data through focus groups and a "library use satisfaction" survey in an effort to "collect qualitative data documenting the needs, behaviors, and values of faculty and graduate students as they search for and use library information and to understand better how clusters of scholars use existing information resources" (p. 365). Scientists in this study were chemistry faculty and Maughan reported chemists searched electronic indexing and abstracting databases, relied on journal literature, and utilized informal channels of communication. Her conclusions agreed and disagreed with past literature. Data were collected through a survey with a response rate was 41% (p. 355), and Maughan reported 91% of the faculty respondents used the library daily or weekly, while they reported less than 7% rated the library's book and journal collections as poor (p. 356). In an article on creating the perfect library, Perlman (1987) cautioned that librarians often use library user surveys to conclude their library is doing a good job (p. 10). Perlman quoted "Howard S. White (1985, p. 70) who wrote that library users' expectations are determined by the resources available in the library and by the level of service their librarians tell them is 'reasonable,' " and he suggested that librarians seek out "irascible grouches" for tangible improvement suggestions (p. 10). While Maughan's research goal, to examine people's information needs and behaviors, was somewhat successful, her results did document the use of the library by library users who returned the questionnaire.

To reiterate, the information world of academics, Ochollo's (1996, 1999) research was focused on information seeking and information use events and he identified several interacting and intervening contextual factors influencing those events including an educator's academic rank, the professional nature of the discipline and its sources, and the local environment. Hertzum and Pejtersen (2000) suggested that the nature of the work task often required greater interaction with informal sources. Again, the local environment, as defined by personal collections and informal exchange of information sources, was valued in satisfying information seeking and use for some engineers and scientists. Soper (1976) examined information use and information seeking events and the intervening factors of formal-informal and external-internal sources and organizing schemes within a local environment. Whether warranted or not, academics perceive building personal/office collections as more desirable than frequenting library collections. Quigley et al. (2002) surveyed information outcomes and information-seeking events. The highest ranking preferences for information sources were concurrent with Soper's results, sources that are most convenient place and time, as well as ones that take the least time to track down. They used certain action terms for managing needs, seeking sources, and navigating less familiar areas, which were acted on by browsing collections, attending meetings, following citation leads, searching collections, reading sources, and consulting colleagues. Quigley et al. mentioned major barriers to information seeking as problematic information retrieval systems, a lack of electronic access to older literature, gray literature, and foreign language literature. These were external contextual intervening factors. Palmer (1991) noted the nature of the discipline and work role, as well as the interdisciplinary nature of subject areas and familiarity with the literature and organization as interacting contextual factors in information needs and behaviors. Hart identified high teaching and service expections as intervening contextual factors, while Maughan's study suggested that information needs and behaviors are satisfied by access and retrieval of resources.

Case (2002) believed that even though the sense-making paradigm is valuable and has revitalized research on information seeking, it does not capture all aspects of information behavior (p. 290). He suggested that it was still valuable to think in *old* terms of source preferences (p. 291) and as several researchers have found, there are intervening factors involved with success and failure in awareness, access, and acquisition of sources. Searing (1992) and Miksa (1998) recognized the lack of fit between interdisciplinary documents and traditional library classification systems. If interdisciplinary topics are not in library systems, then librarians and other scholars will both encounter difficulties in information seeking. Bates (1996) summarized interdisciplinary information-seeking research and declared that "research on information use and information-seeking behavior of people in interdisciplinary fields is sparse to nonexistent" (p. 156). Hurd (1992) adopted a definition that suggests interdisciplinarity is goal oriented and seeks to "answer complex questions, solve problems that are beyond the scope of any one discipline," and ultimately, "achieve unity of knowledge" (p. 19). Bates noted that the value in studying interdisciplinary fields was to inform on the needs and problems of people in those fields and to isolate factors that "contribute to ease and difficulty in information seeking in scholarship" (p. 158). Klein (1996) affirmed this and suggested that "meeting the interdisciplinary needs of today's library users begins with understanding the activities that create these needs" (p. 134).

Information World of Academic Geoscientists

Geoscientists draw upon many different disciplines and fields of study in their work. This was noted by Craig (1969) who determined that 43% of the literature cited by geologists in reporting their research was from subjects other than geology. More than ten years later, Pruett (1982) recognized that geoscientists needed to access a broad array of journals because they often applied physics and chemistry to geologic problems (p. 29). Years later, Hallmark (1998) recognized this lack of mono-disciplinarity. She commented on the "highly interdisciplinary nature of the geosciences" and that librarians who have a background in chemistry, biology, or mathematics would find their knowledge valuable for geoscience subject specialty (p. 85).

Haner (1989) believed geology to be unique among the sciences because a "considerable amount of fundamental research is supported by government publications issued by the United States Geological Survey [USGS] and state geological survey" (p. 123). These government documents form a "stable core of literature" for geoscience information (p. 138), and Haner reported that American and foreign government publications accounted for 16-40% of the cited references (p. 123). High citation rates of government documents correlated with authorship and topic; for example, at least one author was a USGS staff geologist or from a state geologic survey, and more than half of this literataure was on paleontology (p. 123). These references are often from nineteenth century publications, as the USGS was established by Congress in 1879 (p. 123-124). The mission of the USGS as a Federal Agency is to "conduct systematic and scientific classification of public lands, and examination of the geological structure, mineral resources, and products of the natural domain," with a goal to publish and disseminate "earth science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources" (p. 124). Each state survey was created with similar goals on regional scale. Thus, these government agencies have a broad mission, resulting in a wide range of products created by geoscientists who condense this range of subject areas into open file reports, maps, field trip guidebooks, oil and gas well logs, and the like. Additionally, Haner (1989) noted that many of the products of the USGS and state geoscience surveys are not entered into the "Bibliography and Index of Geology or its online equivalent GeoRef" (p. 138).

Incomplete coverage of geoscience publication restricts awareness and access and may necessitate informal communicating and networking. Blair (1993), a former USGS subject specialty librarian and administrator, highlighted this problem in a different way. She warned against using citation analysis as the sole criteria for promotion, awards, and hiring decisions for geoscientists because low citation rates do not necessarily equate with low performance in the geosciences (p. 65). Although citation analysis is used to measure a person's impact on the work of others, it is unrealistic and unfair in some professions, such as geoscience, that produce a high volume of gray literature or products in unique formats with limited publication runs, heavy regional significance, and problematic abstracting and indexing coverage (p. 68).

In addition to these studies on the information world of geoscientists, there are many articles on the use of information, written primarily by geoscience library practitioners. However, two researchers stand out and their findings regarding information use and user in the geosciences will be reviewed.

Gralewska-Vickery

Gralewska-Vickery's (1976) study of Earth science engineers was two-fold: a recognition that library services offered were not being used and a desire to communicate with library clients. Gralewska-Vickery devised a qualitative-quantitative study after realizing Earth science engineers needed many types of information beyond a service her library offered that concentrated on scanning journals. These geoscientists' everyday needs revolved around job tasks performed by people with different roles and different career stages in face-to-face or other types of personal contact situations (p. 281). She illustrated a typical work goal that involved continuous updating of generalized knowledge interacting with experience (p. 258). Gralewska-Vickery diagramed goal success in work tasks and situated experience in a central position (p. 258). This process is adapted and shown in Figure 8. Experience could be gained through personal communication and work, while experience was adjusted to fit the environment and lead to self esteem. Self esteem, which is similar adding self-efficacy as an activating mechanism (Wilson & Walsh, 1996), for information searching, is

Recorded Communication → ← Formal Communication
↓
Personal Communication → | Personal Communication | Leadership Ability
↓ ↓ ↓
Work Object
↓ ↓
↓
Continuous Updating → Generalized Knowledge ← → Interaction → ← Experience
↓ ↓
Ambition → ← Self Esteem → → Adjustment to Environment ↓
↕
Promotion in Work ← ← ←

Figure 8. Professional Communication Diagram. This flowchart follows the relationship between formal and informal communication and personal development. A professional engineer absorbs generalized knowledge through school and work training, as well as interpersonal information exchange. Engineers early in their careers gradually gather experience with continuous contact with colleagues. Interaction stimulates self esteem and ambition that can lead to promotion in the work place. This diagram was adapted from Gralewska-Vickery's (1976) model of goal success in work situations (p. 258).

primary in Gralewska-Vickery's model for goal success. Self esteem could lead to job promotion or could be acquired through job promotion; self esteem could lead to or be acquired through ambition or in lead in the opposite direction to adjustment to the environment (p. 258). Generalized knowledge from personal communication was continuously updated, as well as a mix of formal and recorded communication (p. 258).

Gralewska-Vickery (1976) created a table to show information needs and sources in relation to career stage (p. 262). The career stages were along the vertical axis and progressed from student to junior engineer, intermediate engineer to senior engineer. Across the horizontal axis were information needs and sources including duties, degree of supervision, decisions and leadership, types of information, and sources of information (p. 262). In addition to this matrix of possibilities, the role of the engineer can be distinguished as researcher, practitioner, manager, or linker. She contrasted the difference between researcher and practitioner in that they use "different methods of work, in different patterns of perception, and in the different approach to the end product" (p. 263). An explanation of a participant's perception of the was:

> I think the research man is one who is prepared to be methodical and has a strong tendency to require security in all things. The experiments done by a scientist must be recorded, giving the circumstances under which they have been done. This is done in order that other scientists could repeat the experiments and get the same results. These experiments are done to confirm hypotheses which were anticipated before the experiments started. The results are published and known to everybody who is active in this particular field of science. The practitioner is more

> rough. His satisfaction comes from seeing things done quickly even if the results are not perfect or if he has to cut corners on the way. The research engineer tends to be a perfectionist and is much less cost conscious. The practitioner lives in a situation of compromise in which the most important think is the completion of work, bringing it to a boiling point. (p. 263)

A linker transfers information between pure and applied science and could be a lecturer or professor at a university, as well as a consultant, industrial journal editor, or professional organization (p. 262). When the linker is a teacher, her task is to merge perspectives of the researcher and practitioner, and to present not only what the professional does, but how to be a professional through her curriculum and instruction. To do this, Gralewska-Vickery recognized the importance of personality in effectively communicating between and within industry and academia. Personality was an interacting contextual factor in defining information needs and subsequent behaviors, with characteristics that include communication, cooperation, and credibility. Gralewska-Vickery believed a good communicator must be a confident collaborator, good at providing service, time, knowledge, and judgment (p. 266).

In addition to career stage, work role, and personality, Gralewska-Vickery (1976) believed information sources were intervening factors in information needs and behaviors. Information sources were divided into three broad categories, private, organizational, and external. Private referred to personal knowledge and files, while organization types of sources were defined as colleague knowledge and internal documents. External types are sources outside the person's immediate social network and workplace. Gralewska-Vickery diagramed the interacting paths between sources, the engineer, and libraries (p. 278). Extensive reading can lead to publishing, which leads to society memberships, journal use, literature searches, and greater personal collections and use of libraries. Use of trade literature leads to interest in organization news, which leads to use of external reports and less use of journals; increased visits to the field or attendance at meetings, leads to team discussions and more organizational library services. These paths diverge and coalesce; only rarely leading to dead ends.

Gralewska-Vickery (1976) diagramed the information behavior of an engineer when faced with a problem in a new subfield of the discipline (p. 281), which is shown in Figure 9. It resembles the Leckie et al. (1996) model in part because the latter was based on the former. From the *task* one could go to *internal source-cognitive person* and outcome. However, other directions lead to three external source directions of *primary literature*, *abstracts* and *journals*, or *new subfield discipline*. Two formal source directions lead directly to the *cognitive person*, whereas the *new subfield disciplines* box moves toward *personal contact*, which divides into *advice* to the *cognitive person* or *reading of recommended literature*. *Reading of the recommended literature* does not lead back to the *cognitive person* and at any time *application of new knowledge* leads away from the *cognitive person.*

Gralewska-Vickery's (1976) conclusions were differing personalities, variable job roles, the nature of the work environment, the nature of resources, time constraints, and career stage were some of the important factors interacting and intervening in information needs and seeking behaviors among geoscience engineers (p. 281).

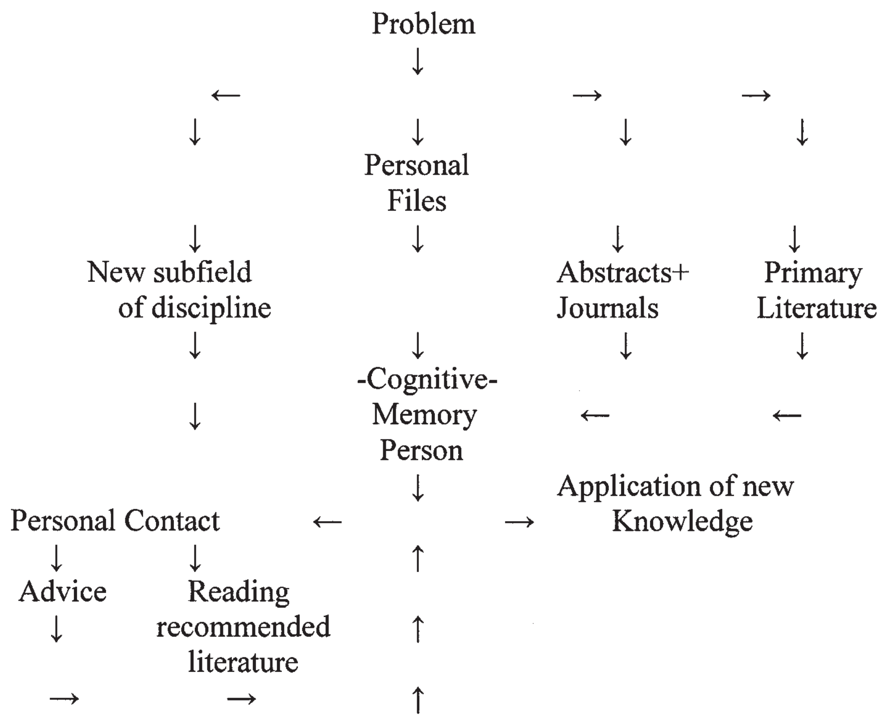

Figure 9. Information Needs Within a Subdiscipline. This represents the flow chart devised by Gralewska-Vickery, who investigated possible barriers to information seeking when the problem situation is outside the geoscientist's specialization but within the geosciences. Thus, a combination of intrapersonal and interpersonal knowledge and information sources may be utilized. This figure was adapted from Gralewska-Vickery (1976, p. 280).

Bichteler Hallmark

Bichteler Hallmark researched geoscientists and their use of information throughout much of her academic career beginning with a study of library instruction for geology students (Bichteler, 1985) to her recent information-seeking of atmospheric scientists (Hallmark, 2003). While much of what is known about geoscientists is published by practitioners, Bichteler Hallmark is possibly the only LIS educator to devote study to geoscientists. She wrote on geoscience libraries (Bichteler, 1990) and the quality of published geoscience information (Bichteler & Ward, 1989b). Hallmark (1998) believed that "the nature of geoscience information posed unique challenges, quite distinct from other scientific disciplines" (p. 87). For instance, Bichteler (1991) identified the need for geoscientists to access a broad array of resource types and formats, as well as data, not repeatable under identical conditions and not disseminated through traditional literature sources. In addition to a focus on geoscientists' information sources, Bichteler Hallmark investigated geoscientists' information-seeking behaviors.

Bichteler (1987) investigated geoscientists' use of GeoRef and found that few geoscientists performed their own information search through any abstracting or indexing database and of those who did responded positively, they were self-taught. Users and nonusers alike complained of the high costs and high lag times experienced in use of this electronic service (p. 49). At that time, Bichteler noted the interdisciplinary nature of the geosciences and suggested that the search strategies that work for a mineralogist or geochemist, may not be right for a stratigrapher or paleontologist and she concluded more investigations were needed (p. 48, 52).

Bichteler and Ward (1989a) interviewed geoscientists representing 17 geoscience specialties according to the 1986 American Geological Institute (AGI). These geoscientists worked in a variety of occupations, work environments, and subject specialties. The researchers had the 57 participants fill out a brief questionnaire, followed by open-ended interviews regarding their research interests, their patterns followed in meeting needs, their frustrations and successes in seeking information sources, and their interest in foreign language resources (p. 170). Overall conclusions were that geoscientists perceived information seeking, access, and retrieval to be costly, difficult, and time consuming and at the time of the survey geoscientists rarely used electronic communication or resources. Geoscientists did not depend on bibliographic database searching; they did depend on personal contacts and personal subscriptions (p. 171). Personal contacts were networks of colleagues and personnel from the USGS and state geoscience surveys, which prompted one participant to go so far as to say libraries were unnecessary (p. 172). Academics stressed the role of their graduate students in keeping them current and one participant volunteered, "The best grad students were browsing freaks" (p. 174). Although some government and private industry geoscientists complained of excessive "red tape" in disseminating their reports, academics complained of the publish or perish syndrome (p. 175). One-third of the participants did depend on foreign language literature, while others complained of the overall credibility issues with foreign publications, as well as poorly organized, overly descriptive reports (p. 176). Bichteler and Ward found that generally geoscientists were uninformed about library services and procedures available to them and that positive information seeking depended on professional position, available time, and constraints set by employers (p. 176). They emphasized the implications for librarians to assist this uninformed, under served user community (p. 177).

After discovering geoscientists do not use abstracting and indexing databases, Bichteler (1991) turned her attention to the products of geoscientists. Bichteler identified geoscience publication types as gray literature. The term gray literature originated with British librarians to refer to "information resources which are not available through conventional channels . . . characterized by limited distribution, poor bibliographic control, small press runs, and nonstandard formats, i.e., literature which is out of mainstream of standard access and acquisition" (p. 39). For example, publication formats include "technical reports, dissertations, government documents, semi-published conference proceedings, and maps" (p. 40). Technical reports, meetings papers, and industry standards are common to engineering and Thompson (2001) described similar problems for engineers with literature not readily available, not properly cited, or indexed comprehensively (p. 57). For geoscientists, this includes open-file field reports, field trip guidebooks, rock-mineral specimens, core samples, geophysical well logs, seismograms, maps, and aerial photographs (p. 40-41). These resources are not found in any one single facility, but archived in many different private and public facilities, although some data sets and information needed by geoscientists are increasingly digital and available online from governmental agencies (DeFelice, 2000; Regan, 2000). Geoscientist's creation of and need for this information is a distinguishing feature of this community of scientists (Blair, 1993, p. 65, 67-68; Lamb, 1999, p. 7), but a frustration for efficient access and acquisition as well. Bichteler (1991) noted that library and information professionals view gray literature with "ambivalence" (p. 40), but she commended the American Geological Institute for assuming the role in improving access to this body of knowledge through GeoRef, a bibliographic database with geoscience citations from 1785 (p. 46). Additional work to improve access to geoscience gray literature has come from the Geoscience Information Society and their Union List of Geologic Field Trip Guidebooks of North America (p. 47), and the Western Association of Map Librarians (WAML) ongoing project to index USGS topographic maps and state survey maps by quadrangle name (p. 45).

Bichteler Hallmark changed her research focus slightly by investigating access and awareness methods preferred by geoscientists. Bichteler (1992) asked geoscientists about their citations to geologic survey publications. She found geoscientists locate survey publications by reading articles, following suggestions by colleagues, or using personal connections to the survey (p. 202). None of the respondents used abstracting and indexing services such as GeoRef (p. 201-202). Hallmark (1994a, 1999) took a similar approach two and seven years later. The 1994 study had a survey response rate of 82% (Hallmark, p. 112) and the 1999 study had a 74% response rate (Hallmark, p. 68). These studies showed a reliance on colleagues and browsing as principal means of finding resources while at the same time, increased use of the Internet by 1999. Geoscientists reported that librarians did not assist in their awareness or acquisition of journal articles and information resources were acquired from library, reprints, preprints, and personal sources (Hallmark, 1994a, p. 112-13). However, in the 1999 study, patterns changed with personal collections being primary to the geoscientist, followed by libraries, which were used less than one-third of the time (Hallmark, 1999, p. 68-69).

Summary

In summary, Gralewska-Vickery (1976) reported on geoscientists as engineers, whereas Bichteler (1987; 1992) and Hallmark (1994a; 1999) looked at geoscientists in academic, governmental, and industrial roles. Pruett (1986b) affirmed this duality when she divided geoscientists into those with patterns of basic scientists and those with patterns of applied engineers (e.g., engineering, mining, and petroleum geologists). Engineering information use meant "targeted, selected, evaluated, digested information," while scientific information use meant the "informal domain for communication" and a great value placed on the scientific journal (p. 145). Pruett detailed geoscientists unique literature needs and desire access to (a) "a wider range of subjects" and use databases such as Chemical Abstracts (for geochemists), INSPEC (for geophysics), COMPENDEX (for engineering geology, rock and soil mechanics), Water Resources Abstracts (for hydrologists); (b) "older material" i.e., obsolescence rates for paleontologists are over a twenty year span; (c) "wider range of formats and use the informal unpublished media," i.e., maps, field-trip guidebooks, theses and dissertations; (d) "literature by geographic area," i.e., Geologic Atlas and Geologic Map Index series or earthquake data from NOAA's World Data Center; (e) "foreign-language materials and their translations," i.e., geology does not conform to political boundaries; and (f) data, i.e., huge quantities, not repeatable, and data not disseminated in literature but through scientist-to-scientist or data centers (p. 145-147). Geoscientists use abstracts and indexes less than other scientists and they have need for hard-copy publications because microfilm readers cannot go out into the field (p. 147). Knowing this, it is easy to see how Pruett (1982) concluded that librarians must utilize different techniques and display formats to handle the literature and raw data required by geoscientists (p. 29).

More recently, Foster (2004) claimed that to understand users' information behaviors investigating sources and the degree of interdisciplinarity in the topic or phenomenon of interest were key (p. 228). This suggests that the problematic bibliographic control of geoscience resources and the nature of the geosciences could impact a geoscientist's world of information, including information uses, needs, and seeking behaviors. Overall, research on geoscientists has shown reliance on personal collections and informal communication with contacts, both colleagues and graduate students, for awareness, access, and retrieval of needed information, while limited use was made of libraries and librarians to satisfy information needs (Bichteler, 1987; Bichteler, 1992; Bichteler & Ward, 1989a; Hallmark, 1994a; Hallmark 1994b; Hallmark, 1998; Hallmark, 1999). Whitehall, Breadmore, and Butters (1989) said it simply, that the major reason for the use and preference of internal, informal channels over primary and secondary literature is that "this is where the required information is known to be available (p. 145). Thus, geoscientists appear to fit the greater trend in information-gathering habits among scientists and engineers that indicate libraries and librarians are not primary destinations or counselors when information is needed (Stuart & Drake, 1992, p. 77-78). How this impacts the geoscience educator in her teaching role remains to be seen. However, past literature about the geoscientist seems to point to the interdisciplinary nature of geosciences and gray literature status as being problematic for both geoscientist and academic librarian and two prime intervening contextual factors affecting information needs, behaviors, and outcomes.

Reliance upon primary literature to support research publications has been confirmed for geoscientists from early library studies that employed citation analysis methods to count and measure the use of literature referenced by geoscientists who published in major geology journals (Brown, 1956; Craig, 1969; Gross & Woodford, 1931). How much of this conclusion is due to the methodology or subsequent interpretation is not known. A number of library and communication research reports have called for a greater interest in information users and less focus on the use of information. Examining information needs and information seeking behaviors of individuals or groups of individuals are major considerations in user studies, whereas counting and measuring the use of library collections, services, systems, and facilities define research on the use of information. Information use studies find that "researchers do not rely on library collections or on librarians to assist them in satisfying information needs or negotiating the complex collections and organizing principles of libraries" (Seggren, 1995, p. 96), and in the case of some scientists and engineers this may be related to contextual factors such as the nature of the work role, discipline, task, and sources. In order to investigate the information needs and behaviors of geoscience educators within a teaching role and curriculum development and instruction planning task, a person-centered, naturalistic approach was adopted to investigate geoscience educators, professionals whose information behaviors are ultimately tied to performing tasks, such as curriculum development and instruction. Methods are detailed in the next chapter.

CHAPTER 4

METHODS

Geoscience library practitioners have conducted the majority of the information studies on geoscientists. Many of these studies had a system-centered focus and sought to determine the use of information collections, systems, services, and facilities. As such, these studies adopted primarily survey questionnaires and citation analysis. Investigating the information needs and behaviors of geoscience educators from their point of view requires a person-centered focus. As such, an interpretive approach and naturalistic inquiry was adopted consistent with a grounded theory study and qualitative research design.

Rationale for Research Design

Geoscience library practitioners have contributed the most literature regarding geoscience use and user, and these professionals belong to the Geoscience Information Society (GSIS), an independent, nonprofit organization established in 1965 with an international membership of librarians, information specialists, and scientists concerned with all aspects of geoscience information (Tahirkheli, 2000, p. iii). This organization is an affiliate of Geological Society of America (GSA), which is one of the foremost professional organizations promoting the geosciences. The mission statement reflects this commitment, "The mission of GSA is to be a leader in advancing the geosciences, enhancing the professional growth of its members, and promoting the geosciences in the service of humankind" (The Geological Society of America, 2005a). "National and international societies with consistent aims and a mission of advancing the geosciences or science can affiliate with GSA as Associated or Allied Societies in order to cooperate in various ways" (The Geological Society of America, 2005b). GSIS is an Associated Society of GSA (The Geological Society of America, 2005b) and they hold their annual meeting in conjunction with the GSA Annual Meeting (Geoscience Information Society, 2005a).

While GSA recognizes the importance of these library practitioners' research and publishes GSIS abstracts, the full text proceedings are published by GSIS (Geoscience Information Society, 2005b). The GSIS annual proceedings are the major publishing venue for disseminating geoscience librarians' research and are indexed in GeoRef. In a review paper of the first 25 years of the proceedings, Derksen and O'Donnell (1995) noted that topics ranged from the pitfalls in database construction (p. 3) to the "peculiar nature of geoscience literature" (p. 4). For the most part, these practitioners have conducted research accounts that are descriptive or evaluative, specific to the researcher's library, and system-centered. For example, Musser (1996) describes the diversity of information resources associated with Earth System Science, a new interdisciplinary movement in the geosciences; Derksen, Sweetkind, and Williams (2000) describe and evaluate the merits of adding Geographic Information Systems software and services to a specific academic library; and Dunn (2001) describes changes in information services and facilities for the public and university specific to her academic geoscience library. These accounts are a wealth of information about geoscience and the use of information by geoscientists and this research does much to provide information related to the management of existing resources and services. Nevertheless, this research approach does little to inform on the information needs and behaviors from the geoscientists' viewpoint.

Although Lamb (1999) described the diversity of geoscience subject areas and the resource types and formats she needed to acquire to complete her geoscience dissertation research, this testimonial from a geoscientist is in the minority of submissions to the proceedings. Only a few studies utilized methods that obtain the viewpoint of the geoscientist directly with regard to their information needs and behaviors, such as Bichteler (1992), Bichteler and Ward (1989a; 1989b), Hallmark (1994a;1999), and Perlman (1987). Instead, practitioners and educators collected data by conducting bibliometric studies (p. 4) and applying survey methods through mailed questionnaires. These methodologies allow for statistical analysis, but avoid direct contact with geoscientists thereby restricting the voice of the group under study.

In order to examine geoscience educators' information needs and behaviors a qualitative approach should be applied. Researchers (Bichteler & Ward, 1989a; Hallmark, 1998; 1999; Perlman, 1987) urged practitioners and educators to adopt a qualitative approach and interview geoscientists directly. Hallmark (1999) wrote:

> It is critical that information specialists be aware of the communication patterns of their users and the real problems which they encounter when attempting to deal with systems at their institutions. To investigate these issues, it seems advantageous to contact users directly and ask specific questions. (p. 67)

In addition, Blair (1993) discouraged citation analysis, one technique of bibliometrics, for describing and evaluating geoscientists' research, because it provides an incomplete view of the information world of geoscientists whose publication formats and citation behaviors differ markedly from other scientists. Furthermore, Palmer (1991) argued that a user's information needs and behaviors could not be discovered by counting and measuring the use of information sources, systems, or services (p. 105). Palmer went so far as to call descriptive user studies that were aimed at measuring the use of services and documents through questionnaires and quantitative means of analysis "conceptual and methodological bankruptcy" (p. 107). To change this trend, this dissertation employs an interpretive approach based on the assumptions of a naturalistic paradigm of inquiry (Lincoln & Guba, 1985) and a grounded theory methodology, which are consistent with the research questions and overall focus of this dissertation.

An interpretive approach is appropriate to frame person-centered research because it is concerned with understanding the world as is, at the level of subjective experience (Burrell & Morgan, 1979, p. 28), where informants construct reality and meaning (Littlejohn, 1999, p. 209). Whereas, it is not possible to construct reality and meaning in advance for geoscience educators, the naturalistic paradigm of inquiry is adopted to allow research findings to emerge and unfold from the participants.

According to Lincoln and Guba (1985), naturalist inquiry starts with a focus of research that determines the procedures that are consistent with research questions; theory emerges from the inquiry and methods are clarified as theory emerges (p. 224). Sampling serves to "maximize the scope and range of information obtained" and although it is not representative, it is contingent upon the study (p. 224). The instrumentation for a naturalistic inquiry is a human investigator, not an objective external mechanism but someone that is a part of the process of research and as such the investigator, "becomes more refined and knowledgeable in that process" (p. 224). "Data analysis is open-ended and inductive" in naturalistic inquiry and "statistical manipulations have little if any relevance" (p. 224).

Lincoln and Guba explained naturalistic inquiry in this way, "What is at issue is the best means to 'make sense' of the data in ways that will, first, facilitate the continual unfolding of the inquiry, and second, lead to a maximal understanding (in the sense of *verstehen*) of the phenomenon being studied in its context" (p. 224-225). Conducting the research in a natural setting, participants' university offices and classrooms, is essential to this research design because the aim of this research is to understand what role information plays in course and instruction development for geoscience educators or in other words, what meaning the phenomena of interest has for the participants under study (Denizen & Lincoln, 1998).

Qualitative Research in Geoscience Education

Qualitative research design has been recommended for geoscience education research. Libarkin and Kurdziel (2002) pointed out that geoscientists have a "long history of using data and analytical techniques" characteristic of qualitative research design (p. 199). As such, they suggested that qualitative analysis is useful in basic research in the geosciences and in course or program assessment (p. 195). An assessment of a course or program is "designed to determine the effect on participants" and basic research is designed to increase a researcher's understanding of a situation (p. 195). Libarkin and Kurdziel recognized that determining effects and understanding situations can be through quantitative or qualitative means and that, "The types of data gathered and methodology to interpret these data will depend upon the inherent goals of the research" (p. 195). They commented that "quantitative data consist of numbers, while qualitative data usually consist of words" and that "all quantitative data are derived from qualitative decisions" (p. 195). Thus in studying science education, they recommended adopting qualitative methodology to obtain "contextually rich information."

Libarkin and Kurdziel (2002) suggested that using the social science tradition of case studies to document details about the phenomenon under study (p. 195). As suggested by Miles and Huberman (1994) for education research, Libarkin and Kurdziel encouraged researchers to use three methods to collect data: (a) interviews, (b) observations, and (c) written documents (e.g., syllabi, assignments, and exams) (p. 195-196). Data analysis themes could be identified through open coding and as links occur in this coding, patterns evolve into conceptual frameworks (p. 197). Instead of statistical analysis, the participants furnish internal validity. "Quotes and anecdotes are useful as examples of the type of data that led to the extraction of themes and connections, and should be used to bolster arguments" (p. 197).

Without statistical analysis, a criticism of qualitative research has been in establishing validity and reliability. While the goal of this qualitative research design is to neither project the findings to all geoscientists, nor to all educators, external validity is not an influential concern. However, Lincoln and Guba (1985) proposed four measures to affirm validity and reliability in qualitative research design including credibility, transferability, dependability, and confirmability (p. 301-331). Internal and external validity can be established through the means of credibility and transferability. In qualitative research, the participants themselves verify interpretations for credibility, while the investigator thoroughly documents the setting for transferability, i.e., detailed descriptions allow subsequent researchers to identify variables inherent to the context of the situation (p. 198). Reliability can be established through the means of dependability and confirmability. In any social science research, reliability is nearly impossible to achieve because people and situations change with time, which is similar to research on Earth and geologic processes that are never static but changing with time as well. Thus, in qualitative research, reliability is controlled for through "keeping careful records, including original notes, transcriptions, and analyses" so as to allow other investigators the opportunity to review the interpretive process (p. 199).

Libarkin and Kurdziel (2002) provided an excellent analogy between the geoscientist's research in the field and the qualitative researcher examining course assessment in the field (p. 199). The geoscientist conducting research on stratigraphy spends time outside looking at the layers of rock as seen in natural cross section beside roads or created sections within quarries. The geoscientist carefully records and constructs field observations in a field notebook. Features are documented with sketches, photographs, and rich text descriptions. The geoscientist use field excursions to investigate the research problem and collect data by going out into the field. For analysis, the geoscientist will synthesize observations and provide descriptions that serve as a conceptual model of the outcrop observed using terminology understood in the discipline. The geoscientist does not publish field notes, rather delimits the findings for interpreting the research problem under study. Although a rock outcrop will change naturally with weathering or artificially with continued mining in a quarry, the geoscientist has established validity and reliability in method that will be repeated worldwide in similar situations.

In a likewise manner, conducting qualitative investigation of the information needs and behaviors of geoscience educators to support their teaching involves going out to the educators' offices and classrooms, collecting data through interview, observation, and course documents. A sketch of the situation, with as much detail as possible, is recorded; analysis involves coding material to highlight important patterns and themes, which leads to a conceptual model of the situation. Interpretation will be synthesizing themes relevant to the research questions, making sense of the findings in relation to past studies, and proposing the value of this research through theory and model to add to the existing body of knowledge in the discipline.

Thus, Libarkin and Kurdziel (2002) encouraged researchers to utilize a research methodology to examine geoscientists in a manner similar to what is natural for geoscientists themselves. They urged reflection on research findings and suggested that researchers to consider Eisner's (1991) general questions on relevancy (a) What sense can be made by comparing research results to literature? (b) Do multiple data sources, or the triangulation of data, agree? (c) Are the results useful and what value is the study to the existing body of knowledge? (p. 197). A grounded theory study is one systematic way to create relevant findings through constant comparisons of data that may lead to theory and model to advance the knowledge in a discipline.

A Grounded Theory Study

Grounded theory is a social science research design with the singular purpose of generating theory and was the design adopted for this research. It was proposed by Glaser and Strauss (1967) and has become "a general methodology for developing theory that is grounded in data systematically gathered and analyzed" (Strauss & Corbin, 1994,

p. 273). Theory is discovered during the study "through continuous interplay between analysis and data collection" (p. 273).

A grounded theory study was chosen to investigate information needs and behaviors of geoscience educators in their role of teaching because this guide to the data collection and analysis process is consistent with the naturalistic inquiry and interpretive approach. A grounded theory study is a direct portrait of informants, where the investigator collects data and analyzes for patterns and themes. Data is analyzed in open and axial coding, delimited with selective coding, and in using this constant comparative method, relevant categories and patterns emerge. These patterns lead to theory, in the form of propositional statements or models, which can then be compared to other theory and models in the literature. Reporting includes embedded quotes from interview communication although participants who will remain anonymous. This overall process of a grounded theory study follows the inductive mode of qualitative research as described by Creswell (1994, p. 96).

Grounded theory studies based on naturalistic inquiry approach has been used in higher education and LIS research. Douglas (2003) adopted a grounded theory methodology in his study of reflective practice for academic faculty supervision of doctoral students, while Friedrichsen and Dana (2005) used a grounded theory approach to determine goals and subject matter related to exemplary biology teaching. Mellon (1986) employed a grounded theory study to find a better way to teach search strategies to students and because of the research design she instead arrived at theoretical statements on students' library anxiety. Mellon claimed that the grounded theory study provided an understanding of people and an unexpected result in identifying the library anxiety that would never have been revealed by measuring the use of library resources (p. 165). Correia and Wilson (1997) used a grounded theory research design to examine managers looking for information, while Calloway and Knapp (1995) did a comparison of two studies that used grounded theory and concluded that it was a useful way of analyzing and interpreting interview information regardless of the data generation or coding methods.

The final example of the usefulness of this research design is from an LIS study by Prekop's (2002), who used a grounded theory approach to investigate collaborative information seeking in a military environmental context. He applied Glaser and Strauss' (1967) open coding to meeting minutes; he created categories from the coding and used this as the basis for his second stage of data collection and analysis (p. 534). The second stage was conducting semi-structured interviews and applying Glaser and Strauss' axial coding; this process helped to identify relationships between the first and second stage categories and Prekop believed information seeking patterns emerged (p. 535). His final stage of analysis was conducting additional interviews and identifying "overarching relationships between the three groups of categories;" selective coding created the key perspective of Prekop's analytical story (p. 535). Prekop said he used grounded theory to guide data collection and analysis. He merged components of the information seeking behavior sequence by Ellis (1989) with the information styles by Palmer (1991) among others, to guide the interpretation of his data codes and categories, and to create his subsequent model of collaborative information seeking.

Thus, grounded theory as a methodology seeks why explanations for social phenomena, not just descriptions, through inductive means or reasoning from observed facts. Glaser and Strauss (1967) proposed this methodology because they believed any propositions, principles, or theories should be grounded in data and that there were alternatives to statistical and random sampling when dealing with social processes. They proposed data collection proceed by means of theoretical sampling, that is a purposive means where data are collected until the researcher judges a saturation point has been reached. Data is analyzed by a constant comparative method that includes coding incidents into categories, integrating and delimiting categories and properties. This results in propositional statements or explanations for the applied area of inquiry.

Research Questions

In order to describe the information needs and behaviors of geoscience educators, it is useful to understand the topics and activities that teaching encompasses and the impact information has on these activities. Thus, the following research questions guided this study:

1. What academic subject areas do geoscience educators use for introductory geoscience curriculums?
2. What resource formats do geoscience educators use in introductory geoscience courses?
3. What are the information preferences, priorities, and concerns of geoscience educators?

Definitions

Abstracting and indexing. "A category of database that provides bibliographic citations and/or abstracts for the literature of a discipline or broad subject area, as distinct from a retrieval service that provides information sources in full-text" (Reitz, 2004).

Academic library. "A library that is an integral part of a college, university, or other institution of postsecondary education, administered to meet the information and research needs of its students, faculty, and staff" (Reitz, 2004).

Bibliographic control. "A broad term encompassing all the activities involved in creating, organizing, managing, and maintaining the file of bibliographic records representing the items held in a library. . . to facilitate access to the information contained in them. . . . and the provision of physical access to the items in the collection" (Reitz, 2004).

Bibliographic instruction. "Instructional programs designed to teach library users how to locate the information they need quickly and effectively. In academic libraries, bibliographic instruction is usually course-related or course-integrated. Libraries that have a computer-equipped instruction lab are in a position to include hands-on practice in the use of online catalogs, electronic databases, and Internet resources. Instruction sessions are usually taught by an instructional services librarian with specialized training and experience in pedagogical methods" (Reitz, 2004).

Bibliometrics. "The use of mathematical and statistical methods to study and identify patterns in the usage of materials and services within a library or to analyze the historical development of a specific body of literature, especially its authorship, publication, and use" (Reitz, 2004).

Citation. "In the literary sense, any written or spoken reference to an authority or precedent or to the verbatim words of another speaker or writer. In library usage, a written reference to a specific work or portion of a work (book, article, dissertation, report, musical composition, etc.) produced by a particular author, editor, composer, etc., clearly identifying the document in which the work is to be found" (Reitz, 2004).

Citation analysis. "A bibliometric technique in which works cited in publications are examined to determine patterns of scholarly communication, for example, the comparative importance of books versus journals, or of current versus retrospective sources, in one or more academic disciplines" (Reitz, 2004).

Cite. "To quote or refer to an authority outside oneself, usually in support of a point or conclusion or by way of explanation or example" (Reitz, 2004).

Collaborator. "A person who works closely with one or more associates in producing a work to which all who participate make the same kind of contribution (shared responsibility) or different contributions (mixed responsibility)" (Reitz, 2004).

Context. "In the most general sense, the entire situation, background, or environment relevant to an event, action, statement, work, etc." (Reitz, 2004).

Cognitive or learning style. "The way a person habitually organizes a problem-solving or learning experience, or consistently receives and responds to information, especially whether the individual prefers content already structured (lecture-style) or is more likely to impose his/her own structure on the material (hands-on approach)" (Reitz, 2004).

Course. "A planned series of encounters with the structure of any single discipline, typically for an age, grade, ability, or interest group of students" (King & Brownell, 1966, p. 122).

Cross section. "In cartography, a diagram of the intersection of a vertical plane with the surface of the earth, showing the predicted geological strata, fault lines, etc., in a generalized rather than detailed representation, with explanatory data often given in the legends" (Reitz, 2004).

Curriculum. "All the required and elective subjects/courses taught at a school or institution of higher learning, usually listed by department and course number in an annual course catalog. Courses required of all students for graduation constitute the core curriculum" (Reitz, 2004).

Database. "A large, regularly updated file of digitized information (bibliographic records, abstracts, full-text documents, directory entries, images, statistics, etc.) related to a specific subject or field, consisting of records of uniform format organized for ease and speed of search and retrieval and managed with the aid of database management system (DBMS) software. . . . Most databases used in libraries are catalogs, periodical indexes, abstracting services, and full-text reference resources leased annually under licensing agreements that limit access to registered borrowers and library staff" (Reitz, 2004).

Discipline. "An organized branch of human knowledge, developed through study and research or creative endeavor, constituting a division of the curriculum at institutions of higher learning" (Reitz, 2004). Typically in Western scholarship, disciplines are organized such that archaeology is in humanities, economics is in social sciences, and geoscience is in sciences (Reitz, 2004). A discipline may be divided into subdisciplines, and for the geosciences subdisciplines reside in eleven subdivisions including geology, economic geology, geochemistry, geophysics, paleontology, hydrology, soil science, engineering geology, oceanography, planetology, and other (Keane, 2004, p. 275).

Electronic resource. "Material consisting of data and/or computer program(s) encoded for reading and manipulation by a computer" (Reitz, 2004).

E-mail. "An abbreviation of electronic mail, an Internet protocol that allows computer users to exchange messages and data files in real time with other users, locally and across networks" (Reitz, 2004).

Exemplary university teaching. According to Hativa, Barak, and Simhi (2001), "clarity and a positive classroom climate" are important dimensions of exemplary teaching (p. 725), although they found teachers needed to adopt "strategies that fit his or her personality, skills, thinking and beliefs, subject matter, students in class, and other factors of the particular teaching context" (p. 726).

Fieldwork. "The gathering of information or scientific data about a subject through observation, interviewing, and other methods of direct investigation, usually conducted in a location closely associated with the topic, as opposed to researching the subject in books and other publications, conducting experiments in a laboratory setting, administering mail surveys, etc." (Reitz, 2004).

Format. "The physical medium in which information is recorded, including print and non print documents" (Reitz, 2004).

Government publication. "Under Title 44, Section 1901 of the United States Code, a government publication is defined as 'information matter published as a separate document at government expense or as required by law. The term is also used in a broader sense to include documents published by local, state, territorial, and foreign government" (Reitz, 2004).

Gray literature. There are several definitions given for these print and non print materials "characterized by limited distribution, poor bibliographic control, small press runs, and nonstandard formats" (Bichteler, 1991, p. 39). Bichteler included publication types and formats related to geoscience such as open-file field government reports, field trip guidebooks, rock and mineral specimens, rock and ice core samples, geophysical well logs, seismograms, maps, aerial photographs (p. 40-41), as well as remotely sensed imagery. Another definition from The U.S. Interagency Gray Literature Working Group,

> "Gray Information Functional Plan," 18 January 1995, defines gray literature as "foreign or domestic open source material that usually is available through specialized channels and may not enter normal channels or systems of publication, distribution, bibliographic control, or acquisition by booksellers or subscription agents. . . . Organizations that typically generate the largest quantities of gray literature include: research establishments (laboratories and institutes), national governments, private publishers (pressure groups/political parties), corporations, trade associations/unions, think tanks, and academia. A document with an ISBN number may still be classified as gray literature" (GrayLit Network, http://www.osti.gov/graylit/whatsnew.html).

GrayLIT Network is a portal to Federal gray literature that provides search capability to over 100,000 full-text government technical reports in collaboration with the EPA

National Environmental Publications Internet Site (NEPIS), the NASA Jet Propulsion Lab Reports, and the NASA Langley Technical Reports, to name a few (http://www.osti.gov/graylit). GrayNet (2005), an online Gray Literature Network Service founded in 1993, defined it as "Information produced on all levels of government, academics, business and industry in electronic and print formats not controlled by commercial publishing i.e. where publishing is not the primary activity. (Luxembourg, 1997 - Expanded in New York, 2004)." The goal of GrayNet is to facilitate dialog, research, and communication between people and organizations associated with the field of gray literature. Reitz (2004) defined it as,

> documentary material in print and electronic formats, such as reports, preprints, internal documents (memoranda, newsletters, market surveys, etc.), theses and dissertations, conference proceedings, technical specifications and standards, trade literature, etc., not readily available through regular market channels because it was never commercially published/listed or was not widely distributed. Such works pose challenges to libraries in identification, because indexing is often limited, and acquisition, since availability is uncertain. Absence of editorial control also raises questions of authenticity and reliability. Alternative methods of supply and bibliographic control have evolved in response to the need to preserve and provide access to such material. In the United States, the gray literature of science and technology is indexed in the NTIS database. Theses and dissertations are indexed and abstracted in

Dissertation Abstracts International and are available in hard copy via Dissertation Express.

Information. According to Case (2002), it is "any difference you perceive, in your environment or within yourself" (p. 5). Reitz (2004) expanded this to "Data presented in readily comprehensible form to which meaning has been attributed within a context for its use. . . . More concretely, all the facts, conclusions, ideas, and creative works of the human intellect and imagination that have been communicated, formally or informally, in any form."

Information need. "A recognition that your knowledge is inadequate to satisfy a goal that you have" (Case, 2002, p. 5).

Information behavior. According to Case (2002) to encompass "information seeking as well as the totality of other unintentional or passive behaviors (such as glimpsing or encountering information), as well as purposive behaviors that do not involve seeking, such as actively avoiding information" (p. 5).

Information seeking. "A conscious effort to acquire information in response to a need or gap in your knowledge" (Case, 2002, p. 5).

Information retrieval. "The process, methods, and procedures used to selectively recall recorded information from a file of data. In libraries and archives, searches are typically for a known item or for information on a specific subject, and the file is usually a human-readable catalog or index, or a computer-based information storage and retrieval system, such as an online catalog or bibliographic database. In designing such systems, balance must be attained between speed, accuracy, cost, convenience, and effectiveness" (Reitz, 2004).

Information science. "The systematic study and analysis of the sources, development, collection, organization, dissemination, evaluation, use, and management of information in all its forms, including the channels (formal and informal) and technology used in its communication. Compare with informatics and library science. See also: information theory" (Reitz, 2004).

Information studies. "An umbrella term used at some universities for a curricular division that includes library and information science (LIS) and allied fields (informatics, information management, etc.)" (Reitz, 2004).

Information system. "A computer hardware and software system designed to accept, store, manipulate, and analyze data and to report results, usually on a regular, ongoing basis. . . . information systems can be broadly classified as spatial or nonspatial, depending on whether the data refers to a system of spatial coordinates" (Reitz, 2004).

Information world. For the purpose of this study, the *world of information* or *information world* will be used so as to include information needs and behaviors unique to individuals or sets of individuals.

Interdisciplinary. Subject area related to one or more disciplines or a hybrid subject relying on several subdisciplines or partial elements of disciplines (Foster, 2004, p. 230).

Interdisciplinary journal. "A scholarly periodical that publishes articles of primary interest to researchers in two or more specific academic disciplines or fields" (Reitz, 2004).

Interlibrary loan. "When a book or other item needed by a registered borrower is checked out, unavailable for some other reason, or not owned by the library, a patron may request that it be borrowed from another library by filling out a printed interlibrary loan request form at a service desk, or electronically via the library's Web site. . . . Interlibrary loan is a form of resource sharing that depends on the maintenance of union catalogs. The largest interlibrary loan network in the world is maintained by OCLC, which uses the WorldCat database as its union catalog" (Reitz, 2004).

Knowledge. "Information internal to the intellect" (Greer, 1987, p. 4), including the acquisition process (P. Wilson, 1977, p. 9). P. Wilson noted that acquiring knowledge can be both theoretical and practical (p. 9). "Information that has been comprehended and evaluated in the light of experience and incorporated into the knower's intellectual understanding of the subject" (Reitz, 2004).

Learning-centered paradigm. According to McManus (2001), it is focused on the "classroom technique of students' learning actively under an instructor's facilitation" (p. 424).

Liaison. "In academic libraries, librarians are often assigned one or more academic departments for which they serve as intermediary between the teaching faculty and the library. . . . Most liaison librarians have academic preparation or at least some level of expertise in the disciplines they serve" (Reitz, 2004).

Librarian. Rubin (2000) defined the librarian as one who reduces information anxiety for people through: (a) collecting, organizing, and disseminating the products of information creators; (b) negotiating collections, systems, and services with other information disseminators such as vendors and government agencies; and

(c) understanding information users, and subsequently serving their information needs with instruction and provision (p. 2-4). Academic librarian faculty are, "The professionally trained librarians employed at an academic institution that grants faculty status to librarians" (Reitz, 2004).

Library. Donohue (1973) defined the library as, "An agency for the management of human records" (p. 7), while Rubin (2000) expanded on this to say, "overall, the library can be viewed as an institution involved in the dissemination of information---it is an intermediary between the user and the information that has been created" (p. 4).

Library collection. "The total accumulation of books and other materials owned by a library, cataloged and arranged for ease of access, which often consists of several smaller collections (reference, circulating books, serials, government documents, rare books, special collections, etc.)" (Reitz, 2004).

Library school. "A professional school or department qualified to grant the post baccalaureate degree of M.L.S. or M.L.I.S., supported and administered by an institution of higher learning to prepare graduate students for employment in professional positions in libraries and as information service providers. . . .The term is becoming archaic as more and more institutions use "library and information studies" or simply "information studies" to describe the expansion of their LIS schools to include allied fields (informatics, information management, etc.)" (Reitz, 2004).

Library use. "The extent to which the facilities and resources of a library are actually used by its clientele. Common measures include overall or per capita circulation, turnover of collection(s), gate count, program attendance, Internet use within the building, interlibrary loan and reference transactions, etc. Statistics on library use are important in documenting effectiveness and justifying funding" (Reitz, 2004).

LIS. "An abbreviation of library and information science and library and information studies" (Reitz, 2004).

Literature. "A body of thought as expressed in published writings" (Donohue, 1973, p. 1).

Map. "Any two-dimensional representation of all or a portion of the surface of the earth of another celestial body, the heavens, or an imaginary geographic area, normally done to scale on a flat medium but increasingly in digital form. . . . Maps are categorized by the type of content and method of presentation. See also: aerial map, astronomical map, bathymetric map, cadastral map, cartogram, chart, choropleth map, city map, compiled map, contour map, decorated map, dynamic map, facsimile map, geologic map, historical map, hydrologic map, index map, inset map, interactive map, manuscript map, mental map, multimedia map, old map, outline map, photomap, planimetric map, political map, rare map, reconnaissance map, relief map, road map, schematic map, sketch map, strip map, tectonic map, thematic map, topographic map, wall map, and world map" (Reitz, 2004).

Networking. "The art of developing contacts within a profession and using them to advance one's work and career" (Reitz, 2004).

Person-centered research. According to Case (2002), as research on "individual users, their needs (as they saw them), where they went for information, and what kind of results they experienced" (p. 6). A.k.a. user-centered research.

Science. Drummond (1999), a geoscientist who created a university course to facilitate scientific thoughtfulness in non-science majors, explained "science is not about the collection of factual data, nor is it centrally concerned with the search for universal or even limited truth. . . . Science is, at its core, both a mode of thought and a powerful, successful mechanism for the rational exploration of nature" (p. 45).

Subject. "Any one of the topics or themes of a work, stated explicitly in the text or title or implicit in its message. In library cataloging, a book or other item is assigned one or more subject headings as access points, to assist users in locating its content by subject" (Reitz, 2004).

Syllabus. "An outline of the topics to be covered in a formal course of study, given in the order in which they are to be discussed in class, with any assignments and related readings also indicated" (Reitz, 2004).

System-centered research. According to Case (2002), a system-centered research study of information artifacts and venues where a researcher's focus is on "information sources and how they were used" (p. 6).

Teaching-centered paradigm. According to McManus (2001), this is "the traditional paradigm of higher education. . . . centered on the classroom technique of a lecturing instructor transferring information to passive, note-taking students" (p. 423)

Textbook. "An edition of a book specifically intended for the use of students enrolled in a course of study or in preparing for an examination on a subject or in an academic discipline, as distinct from the trade edition of the same title, sometimes published in conjunction with a workbook, lab manual, and/or teacher's manual. . . . Academic libraries generally do not purchase textbooks because, for most subjects, they become outdated quickly, but a textbook received as a gift, usually from a faculty member, may be added to the collection if the need exists" (Reitz, 2004).

Thesaurus. "an alphabetically arranged lexicon of terms comprising the specialized vocabulary of an academic discipline or field of study, showing the logical and semantic relations among terms, particularly a list of subject headings or descriptors used as preferred terms in indexing the literature of the field" (Reitz, 2004). In the geosciences, the GeoRef Thesaurus helps to navigate the GeoRef database.

Underserved. "Persons within the geographic area or clientele served by a library or library system who use its services infrequently for a variety of reasons, including limited awareness of available resources and services, lack of familiarity with the national language, illiteracy, poor health, lack of transportation, etc." (Reitz, 2004).

Delimitations and Limitations of this Study

While this study investigates information needs and behaviors of geoscience educators, the context is delimited to introductory geoscience curriculum or those courses that involve both geoscience majors and non-science majors. Information needs and behaviors may differ for other geoscience educators teaching the same courses or for geoscience educators who design and implement courses directed at science and engineering majors. Conclusions in this study are limited to these participants.

In addition, because each university had numerous instructors among a diverse introductory curriculum, it was necessary to locate participants through the geoscience department chairpersons. Although these educators are assumed to be the experts on their department faculty, the study delimited choices to one academic semester and as such, the chairperson may have been limited to selecting potential participants by convenience over exemplary teaching.

Finally, the study is limited based on its purposive sample size and restricted geographic range. However, generalized findings to an entire population of educators or geoscientists was never the intent of qualitative research design and validity and reliability are addressed through careful record keeping, participant checks, and the triangulation of methods.

Qualitative Research Design Procedure

Creswell (1994) summarized the main assumptions in qualitative research design based on Merriam's (1988) case study research in education (p. 145). Qualitative researchers are concerned with process and interested in meaning that is "how people make sense of their lives, experiences, and their structures of the world" (p. 145). Qualitative researchers are the primary instrument for data collection and analysis and the research involves fieldwork or physically going to the participants to record and observe in their natural setting (p. 145). "Qualitative research is descriptive in that the researcher is interested in process, meaning, and understanding gained through words or pictures" (p. 145). Finally, qualitative research is conducted through an inductive process where the researcher builds concepts and theories from details (p. 145).

Studying the nature of the discipline and sources educators rely upon from their viewpoint may identify intervening elements that help or hinder the process of course development and effect information behaviors to satisfy information needs for planning course and instruction. Studying course goals, expectations, and requirements, as well as instructional style, from the educator's viewpoint serves to illustrate their perceived information needs and behaviors. Consequently, various techniques in research design are be used to assure results of this research are dependent upon procedure.

Access and Membership

The role of the investigator is of special consideration in qualitative research, which arrives at conclusions based upon assumptions that the researcher is competent as the data collection instrument. Denzin and Lincoln (2000) explained that the researcher's interpretations of the world are shaped by ontological, epistemological and methodological beliefs; "there is no clear window into the inner life of an individual. . . . any gaze is always filtered through the lenses" of the researcher's background (p. 19). The choice of topic for this research is related to this investigator's personal interest in both library and geoscience education. The researcher's background is in the geosciences, having taught since 1988, geoscience courses at a university with a student population around 5,500, and having managed since 1997, an academic U.S. Federal Depository and geoscience departmental map collection. Thus, the topic of this study is consistent with what Lofland and Lofland (1995) suggested that research should start from "where you are" (p. 12). The researcher's own profile enables a physical and psychological access and membership to the setting. However, maintaining a professional distance was important to this investigator, and no attempt to manipulate data or test relationships or theory was made. Instead, the researcher presents an account of the information world of geoscience educator through a shared understanding of the environment, vocabulary, and problems of the study participants (Van Maanen, 1988).

Distance and Verification

When the qualitative researcher is the primary instrument for data collection and analysis, maintaining distance and recognizing reflexivity are important considerations. Qualitative research is interpretive and researcher's reflexivity, bias, and judgment should be explicitly stated in the research report (Creswell, 1994, p. 147). Reflexivity is the *fact* that researchers are a part of the world under study and in addition to being aware of bias, distance and reflexivity are intentionally controlled through careful verification processes in data collection and analysis.

External validity or the extent of generalizable findings is not the ultimate intent of qualitative research design, but careful data recording and coding may allow for limited prediction and generalization if necessary (Creswell, 1994, p. 158). Internal validity or the accuracy of information was addressed by participant checks or feedback from the informants regarding the interview and interpretations of their comments. Reliability or the chance for replicating the study is problematic in qualitative research because the uniqueness of a study with specific contexts and changing individuals work against replication (p. 159). However, Lincoln and Guba (1985) believed both validity and reliability were satisfied and verified through establishing credibility, transferability, dependability, and confirmability and that method triangulation, participant checks, and accurate detailed record keeping were important, as well as reflexive and descriptive notes (p. 301-331).

The researcher's role as the data collecting instrument required descriptive and reflexive notes, as well as recording demographic information. Descriptive notes were the researcher's portrait of the informant, reconstruction of dialogue, description of the digital and physical setting, and accounts of events. Reflexive notes were the researcher's personal thoughts, speculations, feelings, problems, ideas, and prejudices, while the demographic information included times, places, dates, and field setting descriptions. Transcripts of interviews, field notes of the setting and observations, and the memos and coding, as well as transcript and data coding checks by informants are archived. E-mail and print correspondence was archived and organized in notebooks by location and participant.

Data are open to multiple interpretations and the multiple data collection or in this case, methods of triangulation, strengthen this investigator's interpretation. "Method triangulation uses different methods to assess the same aspect of a phenomenon . . . confirming data from different sources, confirming observations from different observers, and confirming information with different data collection methods (Krathwohl, 1998, p. 276). This study was conducted over an eight-month period of May through December, 2004, and three methods of data collection were used: interviews, documents, and observations.

Interviews

Two to three interviews were conducted with each geoscience educator who met research criteria and were suggested by geoscience department chairpersons. Glaser and Strauss (1967) contend that when using grounded theory, the researcher must be clear on the type of participant to enhance the scope of the study (p. 52), but cannot cite an exact number of participants until the research is actually complete (p. 50). The type of participant was an exemplary geoscience teacher who was responsible for introductory geoscience courses and the number of participants interviewed was dependent upon the total choices suggested by the expert, the geoscience department chairpersons, and whether the educator responded favorably to the request for participation. There is less concern with representativeness of a study sample and more concern with the participants' conceptual fit within the study. These sampling parameters are set by the framework of the study and research questions, which were consistent with Lincoln and Guba's (1985) criteria for understanding the phenomena under study (p. 224). The interviews were repeated until coding and categories arrived at through the constant comparative method of grounded theory data collection and analysis were saturated, or no new information was forthcoming. Thus, the study is not fashioned around a preconceived theoretical framework, instead decisions for data collection are fashioned around a theoretical sampling framework. "Theoretical sampling is the process of data collection for generating theory whereby the analyst jointly collects, codes, and analyzes his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges" (Glaser and Strauss, 1967, p. 45).

Documents

Documents were collected from the participant geoscience educators such as syllabi, activities, assignments, exams, power point lecture notes, online course webpages, and a customized laboratory book. Libarkin and Kurdziel (2002) encouraged researchers to collect documents for educational research including representative syllabi, assignments, and exams (p. 195-196). These documents are integral parts of teaching a university course.

Observations

One to two classroom observations were conducted in the 2004 fall semester for each participant's introductory level geoscience course. Creswell (1994) suggested that observations were important to give the researcher firsthand experience with participants and to allow for serendipitous data collection or recognition of aspects not covered through interview or document analysis (p. 150).

Approach to Data Analysis

In this grounded theory study, data analysis was through the constant comparative method. This process as described by Glaser and Strauss (1967) consists of four stages: (a) coding incidents into categories, (b) integrating categories and their properties, (c) delimiting theory, (d) writing theory (p. 105). The process Glaser and Strauss recommended for coding is a sequence that includes open coding, axial coding, and selective coding. The process was summarized succinctly by Creswell (1998):

(a) open coding, where the researcher forms categories and properties; (b) axial coding, where data are assembled to identify the central phenomenon, and explore the interacting and intervening conditions, consequence, and context; (c) selective coding, where the "story line" emerges and propositions or models may unfold (p. 57). In addition, the researcher may display the results in a conditional matrix including the social, historical, and economic conditions influencing the central phenomenon (p. 57).

On the other hand, Lincoln and Guba (1985) modified the constant comparative method process to fit within a naturalistic paradigm (p. 339) and created an operational refinement to complement Glaser and Strauss' (1967) constant comparative method description (p. 344-351). Lincoln and Guba suggested that tasks of unitizing, categorizing, filling in patterns, and member checking (p. 344). They renamed the "coding incidents" as "units of information" that serve as the basis for defining categories (p. 344), which is somewhat related to open coding. The unit could be a word, phrase, or sentence and should have two characteristics, heuristic or information from the participant that provides aid in understanding or direction to action the researcher needs to have or take and motif-like or the smallest piece of information about something that can stand alone and still be interpretable in the absence of additional information other than the overall context (p. 345). Units are found within data, i.e., documents, interview and observation notes, or descriptive, reflexive, or demographic notes, and they suggest that placing units on index cards (p. 346). Lincoln and Guba replaced "integrating categories and their properties" with categorizing, which is somewhat related to axial coding. They suggested that going through the index cards, one by one, and creating or placing each unit into a category pile, which will initially create many categories but fewer as more cards are grouped (p. 348). In the larger category piles, the final outcome is to create a propositional statement; this process is operationalized by combining properties of the units into a provisional rule and then assigning a title to represent the essence of the rule (p. 348). After the rule is established, each card is reviewed for acceptance or rejection and each category is reviewed for overlap and ambiguity (p. 348-349). After this step, all categories should be reviewed again for possible relationships among categories and bridging (p. 350). At the point of saturation in the process, the selective coding or story line will emerge and Lincoln and Guba recommend a member check where the researcher returns to the participant for feedback (p. 351).

In this research, data regarding the subjects that are covered in the course were placed in existing subject specific category codes designated by American Geological Institute (Keane, 2004, p. 275). Also, data regarding the resources that are named for the course were likewise, coded as gray or traditional literature as designated by Bichteler (1991). However, other data were sorted by location and unitized. The initial groups were compared among locations and relational categorizing delimited rules and propositional statements or models.

The Study

Ethical Concerns

The dissertation study began after the dissertation proposal was formally accepted. First, an application for approval to use human subjects was submitted to the Emporia State University Institutional Review Board for the Treatment of Human Subjects in May, 2004 (See Appendix B). An informed consent form (Appendix C) and sample interview questions (Appendix D) were included with the application as directed by the review board guidelines. The application for research was approved in late May and the informed consent form was included in all correspondence with potential study participants. People who agreed to be involved with the study signed and returned the form before the researcher initiated any data collection. Even though no ethical, sensitive issues were expected regarding this study, all informants were assured of confidentiality and anonymity, as well as the fact that study findings would be used only for the intended purposes of research. All participants were sent a condensed final report of the study.

Selecting the Participants

The procedure for selecting study participants, or the sample, must be consistent with the overall research design (Krathwohl, 1998, p. 160). The sampling procedure in a qualitative research design is more concerned with choosing individuals who have the information and perspective needed for the investigation, and less concerned with randomly choosing a large number of heterogeneous persons with which to claim a measure of external validity and thereby infer generality of findings to a greater population (Krathwohl, p. 159-162, 171-172). One nonprobability sampling method, purposive sampling, is often used in qualitative research in order to develop an understanding and explanation of the focus of a study from involved individuals (Krathwohl, p. 259-260). Purposive or purposeful sampling is used in case study research to select persons who can show different perspectives on problem, process, or event, and are ordinary, accessible, or unusual (Creswell, 1998, p. 62). Lincoln and Guba (1985) recommended purposeful rather than representative sampling for naturalistic inquiry (p. 102), because purposive sampling increases the "likelihood that the full array of multiple realities will be uncovered and because purposive sampling can be pursued in ways that will maximize the investigator's ability to devise grounded theory that takes adequate account of local conditions, local mutual shapings, and local values" (p. 40). Therefore, purposive sampling was adopted for this study because it is consistent with the intent of the researcher to select geoscience educators who may best inform her regarding the information needs and information-seeking behaviors to support curriculum and course development and instruction. Again, this purposive sampling method will not be representative of all geoscience educators; however, it is not the intent of this researcher to generalize findings to the overall population of geoscientists or educators.

For this study, research participants were drawn from a population of geoscience educators at post-secondary, four-year geoscience degree granting institutions using the purposive sampling, a nonprobability-based sampling method. Additionally, the sampling frame was one of convenience because the potential pools of participants were confined to within an approximate 110 mile radius of the researcher. Four universities that met all criteria were identified using the Directory of Geoscience Departments (Keane, 2004). An additional university in the researcher's home state was considered because it met criteria except that it was approximately 180 miles traveling distance from the researcher. The investigator sought to enlist approximately six to ten informants from among these five universities as the final dissertation sample of study participants.

In order to lessen investigator bias, geoscience department chairpersons were contacted and asked to recommend the potential participants from among their exemplary geoscience educators who taught an introductory geoscience course in the 2004 fall semester. The Directory of Geoscience Departments (Keane, 2004) provided university campus contact information including the physical address, Internet homepage address, as well as faculty information and each department chairperson's name, telephone number, and e-mail address. The researcher carefully examined geoscience department webpages and course schedules for the summer and fall semesters at the five universities as well.

Letters were sent to geoscience chairpersons at the five universities identified in late May 2004. The purpose of the study was explained and names of geoscience educators in their departments who met criteria for participation in this research were requested (see Appendix E). Participant criteria were described as exemplary geoscience educators who taught an introductory geoscience course in the 2004 fall semester. Exemplary teaching was defined in the letter to chairpersons as an educator who delivered clear presentations and created positive classroom conditions, in accordance with Hativa, Rarak and Simhi (2001). Additional elaboration on this definition was made in subsequent telephone contacts.

The letters to department chairpersons were sent in colorful greeting card envelopes in order to stand out among the numerous mailings these administrators must receive. The mailing included the letter of explanation and the approved dissertation proposal abstract (See Appendix F). Additionally, the large-sized envelope easily accommodated a stamped envelope addressed back to the researcher for their responses. The letters were sent between spring and summer semester break and prior to a national holiday; and thus, the researcher did not follow-up immediately on the correspondence. However, when no responses were forthcoming after a full two weeks, the researcher telephoned in early June. Contact was made with four chairpersons in one day and the fifth, the next day. After introducing myself, I was greeted enthusiastically by these geoscience educators who claimed they were keenly aware of the mailing and several mentioned it was "at the top of the pile." Two people commented directly on the oversized colored envelopes in a positive manner. One department chairperson said it was a clever idea to make her take notice, while another in a jovial manner expressed some disappointment in not receiving a greeting card with the mailings. Even though the chairpersons were familiar with the request, it was obvious from the conversations that everyone needed to hear more about the proposed project and their role in the process. The telephone exchange served to show that although these geoscientists were thinking about the request, confusion had been a factor in the initial lack of response. The researcher answered questions and clarified her intent by providing additional information about the project. One chairperson found the phrase "exemplary teacher" problematic and stated that the faculty member for the fall semester merely lectured in his introductory class. The chairperson suggested that an alternative introductory course because the teacher fit the criteria although he was concerned that the course did not fit my needs. I assured him it did and his suggestion proved successful and productive. Another department chairperson stated he was reluctant to put in writing his assessment of potential faculty participants, but gladly shared a strategy on the telephone that I should adopt to convince each individual faculty to participate. He insisted if I was successful in getting one to say yes, the others would follow. Ultimately, all telephone calls ended with recommendations for one to three potential educators from each of the five schools. Recommendations of potential participants included names of twelve instructors who met guidelines. Each chairperson was thanked for their assistance on the telephone and via e-mail. Two even volunteered themselves as participants for the study, although one never replied to mailings; that person was dropped from consideration.

In two instances, when speaking with the department chairperson via the telephone, the researcher actually volunteered educators' names that had been found online as teaching the introductory course in the fall as possibilities. In one instance the suggestion was not enthusiastically received but contact was encouraged; and in fact, this faculty member did participate in the study although she was slow to respond initially to my requests. In another situation, the potential participant did not end up in the study. During the telephone contact, the chairperson acknowledged hearing the suggested educator's name, but stated it would be this faculty person's first time to teach the course; he never mentioned the faculty member again in the conversation, but did volunteer extremely positive remarks about the other two teachers he suggested. Although all three of these educators were contacted, the professor "new to the course" eventually declined to participate. This "new to the course" educator detailed his busy research schedule for summer in several e-mail messages. The investigator interpreted this to mean I should wait to contact him again in August after the start of the semester. However, his response to a late August email invitation to participate and initiate a date for the first interview, the professor explained that he would be "willing to sit for a single informal interview, or rather a conversation" and he went on to say in personal communication,

> I think your project is interesting, but I find myself unwilling to accommodate myself to some of the procedures you have indicated you will use. If you still wish to talk with me, you are welcome to take notes, but I do not wish to be taped. I will provide you with a copy of my syllabus, but I cannot grant you permission to attend any of my lectures. I will be most unwilling to respond to questions of a quantitative nature. I will sign no 'informed consent documents.' In other words, I fear that in talking to me you will be frustrated in your efforts at formal 'data collection.' But I would be delighted to talk with you in a general way about the subject of your dissertation research. (pers. comm., 8/24/04)

Ironically, there had been absolutely no mention of quantitative questions in our email and classic mail exchanges. We did have a brief encounter face-to-face in early September in which I thanked him for his consideration, and I wished him well with his semester. He reiterated his concerns with my study and said he would have nothing to contribute in any case because he was not a geoscientist, rather a cultural geographer. At his university, the department of geoscience had recently been merged to include geology, environmental, and geography programs.

Print and e-mail correspondence went to the twelve educators, who had been recommended, in early June 2004. Numerous email exchanges followed. Although one of the three potential participants from the most distantly located university responded negatively, he sent a webpage address to view his online course materials. His two colleagues did not respond and through private communication later in the year, the researcher was informed that faculty thought the great distance was unrealistic for effective participation and decided as a group not to respond positively. The final determination of the sampling frame for the study was based on the individual's decision to participate or not, and although the researcher believed nine educators were in place by June, the final sample in August 2004 was seven participants from among four universities.

In the initial contact with potential participants, a formal print letter (see Appendix F) was sent, again using colorful oversized envelops and follow-up email communication. Informed consent forms were included in this initial mailing as well as the approved dissertation proposal abstract (see Appendix C). Included in the mailing was a self addressed stamped envelop, in which the informed consent form could be returned to the researcher, signed and dated, if the educator affirmed intent to participate. The researcher did not anticipate the consequences for adding her own return address sticker on the response envelope and not typing the potential participants' names below the signature lines. Two letters were returned with consent forms that had illegible signatures and the researchers return address label made the identification of the participant problematic. However, the postmark combined with the process of elimination eventually matched the informed consent with the participant. If the researcher's name was below the signature line, confusion would have been alleviated.

The Participants and Settings

University faculty voluntarily report to the Directory of Geoscience Departments, which in 2004 was in its 42nd edition. The directory includes colleges and universities worldwide, as well as state geological surveys, from Alabama to Wyoming, and federal agencies from Argonne National Laboratory to Smithsonian Institution. Keane (2004) noted that this was the first edition that allowed individuals to update their own records online and 6,168 faculty and staff listings were verified for the demographic information and e-mail addresses (p. iv). The directory lists 1,047 geoscience departments, with 940 in the U. S. and of these departments, 814 are degree-granting (p. iv).

According to 2004 AGI directory, the four schools participating in this research varied from listing 41 to 136 students majoring in the geosciences, while their university homepages recorded overall 2003-2004 enrollment from over 14,000 to nearly 30,000 students (Keane, 2004). The smallest of these universities, with over 14,000 students had two faculty members participate in the study, one assistant professor and one associate professor, from among the ten full time and five emeritus, according to the AGI directory; the university offers undergraduate, master, and doctorate degrees in the geosciences. The next larger school, with approximately 15,000 students, had one part-time lecturer participate in the study, from among a faculty of five full-time and three emeritus; the university offers undergraduate and master degree programs (Keane, 2004). A school with a student population of over 19,000 contributed three participants, one graduate student, one assistant professor, and one full professor, according to the AGI directory; this school offers undergraduate and master degree programs and has nine full-time faculty members and one instructor (Keane, 2004). The largest school participating has a student population listed as over 29,000 and one full professor participated in the study. This geoscience department offers undergraduate, master, and doctorate degree programs and has sixteen full time faculty, sixteen adjunct faculty, and eight emeritus (Keane, 2004). Curiously, the universities with the smallest student enrollment are located in the largest cities, while the largest enrollment universities are in smaller cities. The mid-western university cities range in size from over 42,000 to over 440,000, although the largest city has a greater metro population over one million.

Participants' teaching career stage ranged from first year graduate student to a 40 year full professor. There were five female and two male educators, who listed their expertise or subject specialty areas as tectonics, atmospheric science, structural geology, seismology, micropaleontology, earth science, and earth science education. Undergraduate and graduate degrees held by the participants were from Pennsylvania State; The College of Wooster, Ohio; Stanford University; Colorado School of Mines; Kansas University; Kansas State University; University of California at Los Angeles; University of Colorado; Massachusetts Institute of Technology; Petroleum University, China; Ahmadu Bello University, Zaria, Nigeria and University of Ibadan, Ibadan, Nigeria. Post graduate and work experiences listed were at the Cooperative Institute for Research in the Atmosphere, Colorado State University; Geophysics Department, Tel Aviv University, Isreal; Swiss Technical University, Zurich, Switzerland; Sweetwaters Sanctuary Game Reserve, Kenya; USGS EROS Data Center, Sioux Falls, South Dakota; USGS, Denver, Colorado; Geotechnical Engineering, Palo Alto, California; major university museum; editors for major serial publications.

Coincidentally, three of the geoscience buildings visited by the researcher were built with beautiful limestone blocks with a castle-like appearance. The fourth geoscience campus building was contemporary and brick. Two of the buildings were vintage inside, while the other two had been updated. At one university setting, the educators' offices were all contained within a single complex with a type of panopticon arrangement. The geoscience office complex was on the top floor and the outer hallway was narrow and all doors along the way were shut with signs explaining room usage (e.g., a specific laboratory, graduate student offices, or classroom). Upon entering the geoscience office complex, one was greeted by the secretary in a semi-open lobby surrounded by solid doors, i.e., doors without windows, leading into rather narrow offices. The chairperson's office was directly opposite the entry door and from his vantage point; he could gaze at most of the office doors as well as the lobby area and secretary. At this school, of the two participants, the associate professor had an office with a window, while the assistant professor had an office without a window. Both offices were carpeted, with built in bookcases, customized wrap around desks, and four drawer file cabinets. The offices were messy but functional, and both educators had family pictures prominently displayed. The windows did not look functional and central air and heat was obvious. Each office was big enough for a second chair and some of the interviews were held in the office, although one was held in a nearby restaurant and another in the educator's home when her son was ill and she requested the researcher come to the house for the interview.

At another research setting, a vintage building contained classrooms and offices with high ceilings, tall windows, and highly waxed but sloping, squeaky wooden floors. Classrooms were on the first floor, offices on the second floor, and laboratory equipment in the basement level which was known to flood on occasion. The graduate student office was next to the chairperson's office, which was just down the hall from the separate main office room with secretary, copy machine, etc. In the other direction from the chairperson's office was a large carpeted conference room with an enormous modern table and comfortable office chairs. Each of the offices had cast iron heating registers below the windows, individual air conditioning units placed at the very top of the tall windows, and pigeons nesting on the ledge outside the windows. One participant, the graduate student, shared a small room with another student and each had a desk opposite one another, with a shared book case. The laptop computer was personal and although family pictures were prominent, the room was uncluttered. The wooden door to this office had a large glass window, which looked straight through to a west facing window between the two desks which faced north and south. That interview was held in the laboratory room in which she taught. The chairperson's office consisted of a large outer office, which led into large inner office. The outer office was filled with maps, rock and mineral specimens, and other field equipment. There was a path open to walk into the inner office. This office had an entire bookcase wall, three four drawer file cabinets, and three desks, one of which was an antique oak roll top. The floor was filled with journals, sorted into piles, and papers and materials were spilling out of the file cabinets and falling off of the desks. There were two computers and she complained that her main computer had recently crashed and she was attempting to recover files from the hard drive. Also, she explained that she was cleaning and sorting through course papers as well as her journal collection, which would be offered to the student reading room within the building. The third participant at this school had a small office on the opposite end of the building. It had an east facing window, a desk, bookcase, four drawer file cabinet, and two chairs. It was functional and organized.

The third university setting was another stately building from the outside, with high ceilings and terrazzo flooring. The main geoscience office was on the basement level along with educator's offices, research museum specimens, and the like. To get to the participant's office, you had to be admitted through an outer office with a secretary. The outer office had several chairs and an extensive variety of journals to browse. The educator's office was quite large and although the wall you saw upon entering had a wide orange mini-blind with slats closed; however, it may have been a "blind" because this room was in the basement level and a window was unlikely. There was fluorescent lighting on the ceiling but it was not turned on. The room was dark and lit by desk lamps and an interesting "electric log" fireplace that was on when I visited in June and September. There were numerous furniture pieces around the room, bookcases, and interesting artifacts on the walls and desks. This educator is tall and slender, and he sat behind a large wooden desk in a tall backed black leather office chair. The desk was clean and organized, and his computer was on another desk that created an L workspace. The place I was directed to sit was a type of chair designed for a tall person to relax in. If I had sat back in the chair it would have been problematic to see over the desk. Thus, I was perched on the edge of the chair in order to take notes and see the participant, who was always accompanied by his stout bulldog.

The fourth university setting was the contemporary brick building. The geoscience department offices and classrooms were on the first floor which was not at ground level because the lower level was not completely underground so that most rooms on all floors had windows. The flooring was vinyl tiles and some interior walls were brick as well, especially in the classroom. However, the participant at this university was a part-time lecturer and had a small but comfortable office. There was a main desk and some narrow tables creating a U shaped configuration. There were book shelves on the wall above the tables and four drawer file cabinets. There were many papers, journals, and books scattered about, and she was using a personal laptop computer. Although the building had central control of the temperature, she complained of a musty smell in the lecture room she taught in.

Conducting Interviews

Initial interview iterations were arranged with four participants in June at two different universities and three in August and September at the remaining universities. Second and third interviews were conducted from August through December. Initial interviews were expected to last less than an hour, whereas second and third interviews were less predictable in length of time taken. Initial interviews were designed to gather basic demographic information, as well as educators' course goals, ideal expectations, and content breadth or subject area preferences. Preferred resources for course instruction and any barriers associated with information types and formats beyond the textbook needed to accomplish stated goals were explored as well. Second or third interviews were customized to participant and focused on interpretation of the initial interview data and revisited topics based on the overall results of the first interview.

In-depth semi-structured interviews with open-ended questions were conducted face-to-face, although some follow-up questions were asked and answered via e-mail. The interviews had an opening statement and key research questions and probes followed (See Appendix D). Interviews were audio recorded and transcribed by the researcher. Transcriptions were printed and given to the interviewee for confirmation as to the accuracy of the encounter and interpretation. A form for the participant to sign and provide comments or to note changes was included, although the introductory paragraph of each letter was personalized to reflect each encounter (See Appendix G). The transcriptions were made available to participants within a few days to two weeks by way of traditional mail service, in 10 x 13 inch manila envelops. Participant checks were conducted to verify the contents of each transcribed interview. The mailing included cover letter and participant check form, along with the transcript placed in a colorful paper folders and a stamped, self-addressed envelope. The participant's return address was added to the return envelope. The cover letter explained the process and welcomed comments on the participant check form and notes directly in the transcript. If the educators believed the transcript to be an accurate account of the interview, they were asked to sign and date the form and return form and transcript in the mail. Although nearly everyone noted changes in the transcript, they were grammar and spelling except in one case, where the educator placed a question mark in the margin without explanation. The researcher followed up on this via email by going back to the first interview to quote the passage that reference had been made to in the second interview that the participant had questioned. Some demographic, descriptive, and reflexive notes taken before and after the interview sessions were tape recorded and archived, but not always transcribed and certainly were not sent to the participants.

Foster's (2004) interview questions were reviewed for this study of the information needs and uses among research and teaching academics. A "postinterview comment sheet" was used to the guide for material not shared with the informant and field notes on the interview after the interview is concluded (Lofland & Lofland, 1995, p. 83). Appendix H shows the interview guide face sheet that had the interviewee's name, assigned code number, date of interview, place of interview, sex, education, occupational title, etc., as suggested by Lofland and Lofland (1995, p. 83). When preparing for the interview, various *equipment* and items were assembled including tape recorders, blank tapes, spare batteries, interview question guide, two pens, blank field notebook, watch, as well as quarters for parking meters for university parking lots. The researcher arrived at the destination in advance to locate offices and classrooms.

Collecting Documents

Curriculum materials were gathered at the first interview, while a date for classroom observation was set at the second interview. The course documents collected varied with participants and included such things as syllabi, sample assignments, activities, power point course notes, sample exams, customized laboratory book, online course web pages, portions of a teaching portfolio, and the like.

Conducting Classroom Observations

The researcher conducted semi-structured observations of lecture or laboratory activity sessions, with general field notes taken during the observations and each session audio-taped. Appendix I shows the observation face sheet. Observing sessions allowed the researcher to see first-hand the mode of presentation of subject areas, topics, and processes, as well as the information formats used in the classroom. A final interview took place after observation sessions.

Data Collection

Collection of data was from June through December 2004. This span of time on a university calendar included summer and fall academic semesters. During this period, 15 in-depth semi-structured interviews and 8 classroom observations were conducted, while approximately 235 pages of course documents were collected. The researcher traveled to each participant's university and collected data from the educator's office and classroom, as well as one restaurant and home. Data collection methods along with subsequent participant checks created a layering of data, which was recommended for a naturalistic inquiry and interpretive research design (Lincoln & Guba, 1985).

Protocol and procedure for interviews and observations were guided by Lofland and Lofland (1995) and Creswell (1998). Interview sessions were from 20 to 70 minutes and were audio tape-recorded and transcribed verbatim. In most interview sessions, two tape recordings were made using a microcasette recorder, GE AVR 3-5375, and a cassette recorder, RadioShack CTR-122 14-1129. The microcasette recorder had a small microphone that attached to the participant's clothing and this created clear reception of the interviewee. In addition, the micro cassette tape was necessary for the researcher's transcribing equipment. However, a verbatim transcript required both interviewee and interviewer comments, and the second tape recording allowed the researcher to clarify interviewer comments not audible on the microcasette recording. Transcripts of all interviews were created in both digital and print formats for each oral session. Single-spaced print transcripts were from 6 to 20 pages in length. Interview transcription took the researcher over 120 hours using a microcasette transcribing machine, the Sanyo Memo-Scriber TRC5040. The researcher used the microcasette recording to add field notes, impressions and reflections of each interview session, directly after the interview. Although these data were transcribed, they were not sent to the participant.

Course documents were obtained at initial interviews with each participant. These data were analyzed after the initial contact with participants and member checked at the second interview. The categories and findings created by the researcher were presented to the participant for interpretation accuracy, additions and corrections, during the second interview. Subject areas covered on the syllabi and reported during the interview, as well as resource types and formats reported by participants during the interview were coded into categories. Geoscience subject areas were assigned to one of the 94 teaching specialty areas found in the Directory of Geoscience Departments (Keane, 2004, p. 275). The resources were organized as gray or traditional literature, and separated into sources unique to geoscience and to instructional media sources.

Classroom observation sessions were from 80 to 120 minutes and audio-taped. The researcher listened to recordings but did not create a verbatim transcript. Class lecture notes and field notes of impressions and reflections were recorded and totaled to 140 pages of handwritten notes. Data collected during classroom observation sessions were used in coding for subject areas and resource types and formats. For instance, after observing one geoscience educator's class, museums were added to the list of resource types because she took her class to the geoscience museum located in the same building as a part of her lecture. Although no participants had mentioned museums during interviews or on their syllabi, several indicated they used museums after I added it as another category.

Data Analysis

Participant's interviews, curriculum materials, and observations were analyzed to identify main subject areas, topics and processes and information formats used to convey essential course materials. During the second interview, geoscience participants affirmed the categories of subject areas, topics and processes identified by the researcher and added or clarified anything the researcher unintentionally left out that the educator would expect to introduce by the end of the course. Additional data were analyzed for emerging themes regarding the educator's goals for the course, including the breadth of content preferences or subject areas to be covered and ideal expectations; and barriers associated with information formats beyond the textbook needed to accomplish stated goals. Chapter Five presents a description of the data collected through the interviews, documents, and observations and subsequent analysis.

CHAPTER 5

RESULTS

The study of geoscience educators who participated in this research provided meaningful data about their information needs and behaviors in developing and planning introductory geoscience courses. Data were gathered from semi-structured interviews, as well as a review of course documents and classroom observations. Research questions guided and engaged participants to discuss overall projected information outcomes, needs, and strategies. Hundreds of pages of correspondence, interview, document, and observation transcripts and notes resulted during the seven month time period, June through December 2004, from seven participants at four universities. Geoscience participants' own words are used to explain their conceptual framework for the role of information in support of teaching.

The results illustrate that geoscience introductory courses begin with projected outcomes for curriculum, as well as the individual participant's personal goals and expectations for course and instruction. Subject areas are delimited and the interdisciplinary nature of geosciences is noted. Defining goals and subject areas highlight information needs. Illustrating concepts within subject areas both visually and physically were strategies used by geoscience participants; projected animations and figures, as well as demonstrations, activities, and assignments are created. Intrapersonal knowledge and personal libraries are relied upon for creating lectures, while interpersonal information, from colleagues and other contacts, is used to gather additional sources and tools, as well as teaching tips and techniques. Formal sources used to support teaching are published or unpublished textbooks and lecture notes, while informal resources include face-to-face or electronic exchange such as an educator to educator or an educator to professional organization (e.g., GSA Blocks of Docs or Digital Library for Earth System Education). Sources and tools are obtained from personal or departmental collections and external primary or secondary sources. Participant's academic library and librarian were not mentioned until the researcher specifically asked about the role of their academic library liaison. For the most part, students were neither encouraged nor discouraged in using their academic library when given geoscience media assignments.

In order to maintain anonymity, actual names of participants or chairpersons are not included and university course numbers are coded. Academic rank and course titles, however, are authentic.

Projected Information Outcomes

Projected outcomes define the purpose of course and curriculum, and provide clues to subsequent information needs and behaviors. An introduction to introductory course curriculum was provided by geoscience department chairpersons while discussing course and educator for this study via the telephone. The letter sent to university chairpersons asking for their suggestions of potential participants for this study contained two stipulations: that the participant would be teaching an introductory geoscience course in the 2004 fall semester and that he or she would be considered an exemplary teacher. The description of an exemplary teacher, as provided by Hativa, Barak, and Simhi (2001), was included in the letter (See Appendix E) and on the telephone. Hativa et al. reported that educators who provide positive classroom conditions and excel at clarity of concepts, making content relevant by citing applications and connecting course goals to experiences of students, demonstrate exemplary teaching (p. 728-729). Geoscience department chairpersons recommended the introductory course and the participants for this study.

An examination of university online course offerings revealed that some introductory geoscience courses had a broad focus [e.g., the course titled, "Understanding the Earth"], while others had a narrow focus [e.g., the course titled, "Oceanography"]. One chairperson interpreted my request as limited to an introduction to geology course and this presented a problem in his response. The chairperson from the university with the largest student enrollment represented in the study explained that while multiple sections of an introductory geology course were taught in the fall semester, he was "in a quandary over the request for exemplary teaching" (Chairperson A, personal communication, June 8, 2004). He said, "this [exemplary teaching] was the hang-up because teachers in this introductory course do not do anything innovative and pretty much teach right out of a textbook" (Chairperson A, personal communication, June 8, 2004). Alternatively, he suggested that I consider accompanying Dr. X [who taught introductory geology in the fall] on a two-week summer field methods course or speak with Dr. Y who taught a *wildly popular* introductory course on earthquakes in the spring 2005 semester (Chairperson A, personal communication, June 8, 2004). When I reiterated the qualifications of the study, he recommended that I approach a professor who matched the criteria of exemplary teaching but taught a narrowly focused introductory course that he described as a "bioscience course from a geoscience perspective" (Chairperson A, personal communication, June 8, 2004). He had not initially considered this course because of its singular focus on prehistoric life and although the course has a geology catalog listing, it was, in fact, offered for a distribution requirement for biology majors (Chairperson A, personal communication, June 8, 2004). Chairperson A continued to explain that the course was taught by a paleontologist from the geoscience department, who was a *popular teacher,* and that it was offered for geology majors, but not in fall semesters. This account clearly demonstrates Prehistoric Life is an introductory geoscience course where information outcomes are interdisciplinary - the combination of bioscience and geoscience information and concepts.

Another department chairperson recommended that I include in my study two professors who teach two different introductory courses and two different exemplary teaching styles. Chairperson B (personal communication, June 10, 2004) spoke highly of these two professors, saying one was "headed toward being a star teacher," while the other was a "first rate researcher who took undergraduate teaching seriously, always getting students out into the field." One of the professors was a geologist and the other was a climatologist-meteorologist; both taught a course on general geoscience. Even though both courses fulfill a general science requirement for non-science and geology majors, the latter course is required for geography and environmental studies majors as well (Assistant Professor One, personal communication, September 21, 2004; Associate Professor One, personal communication, September 9, 2004). The geoscience department hosted geology and geography, as well as environmental studies degree programs, even though the environmental studies program is a collaborative effort with other departments such as urban planning and development, chemistry, and biology to name a few (Chairperson B, personal communication, June 10, 2004; Assistant Professor One, personal communication, September 21, 2004).

At the third participating university, the courses recommended by the chairperson were "Earth Science and the Environment," as well as "Oceanography" (Chairperson C, personal communication, June 8, 2004). These classes are for both geology and non science majors and taught by the same instructor. The chairperson spoke enthusiastically about this faculty member, pointing out that she would be excellent for my study because of what she brought to the job as a result of her international geoscience teaching experiences and working in Africa and China (Chairperson C, personal communication, June 8, 2004). Chairperson C (personal communication, June 8, 2004) went on to say that this potential participant fit the criteria for my study best, "All of the faculty taught the introductory course, no one is too important to be exempt, although most do not like to teach it." The teacher she recommended taught sections referred to as telecourses. While campus based courses included in the study met during traditional fifty minute time slots three times a week or seventy-five minute time slots in evening sessions twice a week, these two telecourses were in part, distance learning. Students worked outside class time with textbooks and visual media - commonly videos - yet met in class for 120 minute sessions eight Saturdays during the 2004 Fall Semester.

The final university included in the study had both geography and geology that were separate departments. The geology department chairperson was contacted for this study. Chairperson D (personal communication, June 8, 2004) suggested that the "Earth in Action" lecture class and the Geology Laboratory course for the study. She pointed out that before she came to the university the introductory courses had been revamped and given "snappier, more appealing names." She added that even though the laboratory classes were taught by their undergraduate or graduate geology majors, she highly recommended one particular graduate student for participation in this study (Chairperson D, personal communication, June 8, 2004). This graduate teaching assistant had not only taught the course as an undergraduate student, but would be teaching a section in the fall and coordinating all of the students teaching the course as a duty of her graduate assistantship. Chairperson D (personal communication, June 8, 2004) explained that the student had undergraduate degrees in both geology and education and was trained by a former instructor in the department who specialized in geoscience education. Additionally, the laboratory course was not exclusive to the physical geology introductory section, but served four introductory courses including an Earth history and natural disasters classes among others (Graduate Teaching Assistant One, personal communication, June 18, 2004). Chairperson D (personal communication, June 8, 2004) recommended two others for the study: an Assistant Professor and herself. She explained that she was interested in my study in part because she was an advocate of peer review teaching programs, and she was adopting an e-instruction technique for the fall that would engage students through the use of "clicker" devices (Chairperson D, personal communication, June 8, 2004).

Thus, through their recommendations, chairpersons revealed their interpretations of exemplary teaching and highlighted the interdisciplinary nature of some introductory geoscience course curriculum. Chairpersons described exemplary educators as popular with students, innovative in course design and instruction, as well as first-rate researchers. They described introductory geoscience curriculum through the variety of courses available for geoscience, bioscience, geography, and environmental studies majors, as well as some greater population of non science majors taking courses to fulfill science graduation requirements.

Participants explained that some inherited, while others helped to design, curriculum based on some agreed upon outcome, which they customized with special emphasis of certain topics. Hence, it is essential to examine personal outcomes and how participants think ahead to formulate course and teaching goals and expectations that will meet their projected information outcomes. Details are given on course syllabi, which are distributed to students at the beginning of classes. Thus, geoscience participants' goals, expectations, and outcomes are described along with brief background information on participants.

Personal Goals, Expectations, and Outcomes

Participants' overall personal goals and expectations for course development and instruction were reviewed from syllabi, clarified during interviews, and experienced during classroom observation sessions. Although some outcomes were course specific, participants had common outcomes, goals, and expectations. For instance, all participants were enthusiastic about the geosciences and wanted to pass this excitement along to the student, which created positive classroom conditions. They spoke of creating a sense of what science is and is not and explaining what a geoscientist does in order to clarify the overall conceptualization of science and geoscientist. Although participants had expectations for students to learn geoscience vocabulary and concepts, they did not want memorization without understanding. They indicated that providing geoscience applications and illustrations through visual media or physical demonstrations was essential to sense-making. This is similar to making course content relevant with examples and connections to students' lives (Hativa et al., 2001, p. 729). All participants involved in the study were keenly aware that these courses were taken primarily by non science majors and they believed that fulfilling a science education requirement meant students should be able to make informed decisions based on good science, both content and thinking. Specific examples follow. Table 1 provides a basic summary of participants in this study.

Graduate Teaching Assistant A

Graduate Teaching Assistant A (GTA_A) has taught for two years, and was planning on specializing in igneous and metamorphic petrology, as well as on teaching in the geosciences when she has completed the master's degree program. This participant pointed out that her overall course goal for Geoscience (Geo) 100 Geology Laboratory was for "students to understand how geology is helpful in their lives" (personal communication, June 18, 2004). She explained her belief that this course goal would be met by making the class interesting through emphasizing applications of geology. For an example of how she would do this, she described the geoscience field methods course she was enrolled in the summer, and she pointed out that she would demonstrate and pass on her experiences and new knowledge on volcanoes and igneous rock to students in the fall session (GTA_A, personal communication, August 26, 2004). Because her course is designed as a laboratory class, each class meeting consists of a 20-30 minute lecture followed by hands-on activities (GTA_A, personal communication, June 18, 2004; August 26, 2004). Students go out of the classroom for

Table 1

Background of Participants

Participant	Teaching	Academic Rank	Course Title
GTA_A	< 5 years	Graduate Teaching Assistant	Geology Laboratory
L_B	<10 years	Lecturer	Earth Science & the Environment
L_B			Oceanography
AstP_C	< 5 years	Assistant Professor	Understanding Earth
AstP_D	<10 years	Assistant Professor	Earth in Action
AP_E	<10 years	Associate Professor	General Geology
P_F	<20 years	Professor	Earth in Action
P_G	<45 years	Professor	Prehistoric Life

three separate field trips to physically demonstrate concepts and create excitement through viewing landscapes and collecting specimens (GTA_A, personal communication, June 18, 2004). She reported that her teaching goal was to "make a difference in students' lives" and she advocated an "active learning" or "learning by doing" teaching strategies (GTA_A, personal communication, June 18, 2004; August 26, 2004). Her expectation for students was that they "learn the subject not memorize facts" (GTA_A, personal communication, June 18, 2004; August 26, 2004). She has an informal way with students in the classroom and empathized, saying she could "stand in their shoes" (GTA_A, personal communication, August 26, 2004). The statement inside the locally created textbook sums her expectation and outcome, "We welcome you to the world of geology and hope your experience will inspire you to investigate the world around you long after this class is over" (GTA_A, personal communication, June 18, 2004).

Lecture B

Lecturer B (L_B) has taught in the five to ten year range, and she describes her specialty as environmental science, with a background in diplomatic service and wildlife management at a center in Kenya where she researched human and environmental impact on chimpanzee behaviors (L_B, personal communication, July 13, 2004). L_B (personal communication, July 13, 2004) reported that she designs her introductory courses to show students that the geosciences are not all *math and formulas* and to *hook them* on science. L_B's goal is to debunk misconceptions of science. She pointed out that she wanted to have students "see science as an exciting way to learn about your world and environment," as well as realize that science is a "way of approaching information" and a way of learning and thinking" (L_B, personal communication, July 13, 2004). One expectation is that students realize how the geosciences effect their lives; to accomplish this she assign media reports of local or global current events that she would incorporate into lectures to stimulate discussion relating geoscience concepts to real world examples (L_B, personal communication, July 13, 2004; September 18, 2004). Course goals for Geo 101 Earth Science and the Environment described on the syllabus include understanding the relationship between humans and their environments, both current and historic contexts; visualizing Earth as a constantly changing *living planet*; appreciating geologic time and environmental concerns; recognizing major environmental challenges and debating the choices and tradeoffs the challenges pose to general and personal life; and applying and understanding concepts, issues, and scientific processes (Geo 101 Syllabus, Fall Semester, 2004). The second course, Geo 102 "Oceanography," has more focused goals and objectives including: understanding origins and inhabitants of world oceans; explaining the history and evolution of oceanography as a science; investigating marine environments from physical, chemical, and biological perspectives; and examining the interrelationships between ocean and atmosphere, ocean basins and plate tectonics, marine environment and global climate, and marine communities and resources (Geo 102 Syllabus, Fall Semester, 2004). Both courses are taught in a distance learning mode, which creates challenges for the participant to meet her projected outcomes with limited face-to-face instructional time.

Assistant Professor C

Assistant Professor C (AstP_C) was beginning his third year of teaching and provided a most detailed set of course and teaching goals, expectations, and outcomes. AstP_C (personal communication, December 3, 2004) describes his researching and teaching specialty as atmospheric science, specifically climatology and meteorology. He explained that the geoscience department goal for Geo 103 “Understanding Earth” was to merge introductory geography, geology, and environmental studies courses into one with an interdisciplinary focus on Earth processes and the role humans play in those processes (AstP_C, personal communication, August 4, 2004). He believes this is a *full task*, and as such a balance between content and information overload is important when planning and delivering his course (AstP_C, personal communication, August 4, 2004). As an example, AstP_C said he had sensed anxiety at his last class session and he took time to go over concepts again and answer questions in the classroom session I observed (AstP_C, personal communication, September 21, 2004). When questions arose, AstP_C asked the class to "help him out with the answer" and he created an informal discussion format instead of merely answering the question.

Although AstP_C's main objective is to emphasize the need to understand how the Earth works by focusing on interrelations and interconnections among the atmosphere, lithosphere, hydrosphere, and biosphere, he said each person who taught the course stresses their research specialities (AstP_C, personal communication, August 4, 2004). His course objectives shown on the syllabus include:

> **facilitate** thinking in terms of systems concepts; **gain** perspectives of varying spatial and temporal scales of change; **explore** the complexity of

> relationships between the major subsystems of the earth: atmosphere, biosphere, geosphere, and hydrosphere; **explore** how these interaction change with time through our study of earth system history; and **improve** communication and group interaction skills. (Geo 103 Syllabus, Fall Semester, 2004)

Additionally, AstP_C (personal communication, August 4, 2004) reported he sought to demonstrate what basic science is, including what we know in science and what we don't know in science, as well as the limits to science and to our own understandings. He continued explaining his personal goals, to present science in an interesting and engaging way, create a sense of excitement, and show applications of what we [geoscientists] know (AstP_C, personal communication, August 4, 2004). This was best accomplished by developing the course with two audiences in mind. For geoscience majors, he wants to give a solid foundation with which they can build in subsequent courses; for non majors, he wants students to learn the material deeply enough to make wise decisions regarding natural resource exploitation and to be able to explain geoscience concepts to co-workers (AstP_C, personal communication, August 4, 2004).

AstP_C's (personal communication, August 4, 2004) teaching goals parallel his research approach that is collaborative; just as he expects resarch to be a collaborative, he wants to facilitate students who drive content for lectures and course activities. To accomplish this he employs class debates, written and oral presentations, and group projects (Geo 103 Syllabus, Fall Semester 2004). In a later interview, AstP_C said he realized a month into the class that some of his expectations were unrealistic because students had little to no science background (AstP_C, personal communication, December 3, 2004). In spite of this perceived set back, he still believes he should move from *center stage*, his notes and lectures should be supplemental to the course, and students could be effectively guided in the right direction and take the initiative in the learning process (AstP_C, personal communication, December 3, 2004).

AstP_C talked about this course and overall interdisciplinary environmental science program. Although he believes geoscience is a good host department for the course at present, he stated that "students could drive the process to seek a full department for environmental studies, a bottom-up approach, or faculty collaboration could flourish and develop with good work, good funding, and earn clout in the university system to make demands for change, or a top-down approach" (AstP_C, personal communication, December 3, 2004).

Assistant Professor D

Assistant Professor D (AstP_D) has taught in the five to ten year range and lists her research and teaching specialty as seismology. AstP_D (personal communication, June 18, 2004) wants students to know "what is geology and to realize geologists' work goes beyond hammer and rocks to include such topics as earthquakes." Her course and teaching goals for Geo 104 “Earth in Action” include (a) introducing facts about Earth such as rock used as building materials, (b) understanding Earth's internal processes and external effects such as earthquakes, (c) examining Earth's surface features and processes such as landscape evolution, and (d) explaining how scientists conduct scientific work; and promoting critical thinking and open discussions (AstP_D, personal communication, June 18, 2004). She believes these goals and expectations are met through lectures supplemented with real-life examples from her research and numerous images, animations, video clips, and demonstrations in class and available outside class on her extensive online course web site, which is not password protected. AstP_D adopted the teaching goals and strategies, presented at a workshop in 2001 by Dr. R. F. Yuretich, of the University of Massachusetts, where active learning is encouraged through class activities and innovative exams (AstP_D, personal communication, June 18, 2004). For instance, she uses a *two-stage exam* where the first version is individual, closed book, and the second version, open discussion with classmates (AstP_D, personal communication, June 18, 2004). Additionally, an *Eight-Day Study Plan* is posted on AstP_D's course web page to aid students in preparing for exams, which highlights her personal teaching goal, to help students succeed.

Associate Professor E

Associate Professor E (AP_E, personal communications, September 9, 2004) has taught nine years at this university and lists her research and teaching specialty as tectonics. She was trained as a geologist and archaeologist, and AP_E (personal communication, December 3, 2004) conducts research in paleoseismology and archaeoseismology. Course objectives for Geo 105 “General Geology” are "to learn key aspects of the science of geology, focusing on physical processes, and to learn to think critically, with a degree of skepticism about sciences such as geology" (Geo 105 Syllabus, Fall Semester, 2004). Although AP_E placed the goal statement on the syllabus that students should learn critical thinking, during the interview she indicated it was an unrealistic goal. At the first class meeting, students fill out a questionnaire with their name, email address, major, exam question type preference, expectations for the course, and reasons for taking the course. AP_E explained this information identifies geoscience majors and guides exam questions. In summing her overall goal, AP_E (personal communication, September 9, 2004) said, "I try to make it interesting so they can look around them a little differently than they came in, and she added "to be interesting it must be real" (person communication, December 3, 2004).

ProfessorF

Professor F (P_F) has taught for 15 years and lists her research and teaching specialty as structural geology. She wants students to understand that a knowledge of geology is useful as a decision making tool (P_F, personal communication, June 18, 2004). On the syllabus for Geo 106 “Earth in Action” course expectations include (a) attending class and devoting time outside class to read the text, (b) paying attention to the world around you through personal observation and media, such as news and movies, and (c) and making "connections to the geology we learn about and the geologic features and issues around us" (Geo 106 Syllabus, Fall Semester, 2004). P_F (personal communication, June 18, 2004) went on to explain:

> I want them to realize geology is fun and interesting. I'd really like them to understand processes and how things work. . . but it's tough to balance all that out. I'd like them to read the textbook but the reality is most [of what they get] is what I lecture on; my hope is that for those dedicated students that do read it [the textbook], it fills in the holes, gives them more information, gives them a different perspective.

Thus, one course objective is to introduce aspects of geology including those relevant to a student's life and career (Geo 106 Syllabus, Fall Semester, 2004). This concern for student meaning is aligned with her teaching goal, which is evident in a first assignment. Early in the semester, a homework assignment asks for the student's name, high school, hometown, major, as well as the number of years spent at the university or other schools, and why they are taking the course. P_F (personal communication, June 18, 2004) uses this information to customize the course and bring in relevant examples and applications based on student backgrounds and expectations. For example, if construction science engineering majors are in the class, then she emphasizes the use of gypsum, a natural resource found within this state, as the wallboard in wall and ceiling construction (P_F, personal communication, June 18, 2004). Thus, a teaching goal is to bring real-life situations into the classroom so the students do not simply memorize facts. However, she said some geoscience vocabulary must be introduced such as aquifer, to gain enough practical vocabulary and understanding to realize her projected course outcome so that "when they read about their city's landfill being full or ground water contamination or the aquifer running dry, they know what that means" (P_F, personal communication, June 18, 2004).

Professor G

In contrast to others, Professor G (P_G, personal communication, June 23, 2004) has been teaching at his university since 1965 and lists his research and teaching specialty as paleontology. He designed Geo 107 “Prehistoric Life” as an offering to biology and geology students, and according to P_G (personal communication, June 23, 2004) his course goal is to "give students good background in the biological side of paleontology and cover fossils. I hadn't really thought about goals. My goal is to teach people about prehistoric life." On the course syllabus, he lists a three-fold purpose for the course:

> to present the evidence that bolsters our understanding for the long evolutionary history of life on earth, to explain how geologists and paleontologists use fossils to help them understand the earth's past, and to see what the fossil record tells us about humans' place in nature. (Geo 107 Syllabus, Fall Semester, 2001)

He went on to write that scientists are people and, "I shall present some information on the personalities in paleontology and how people have interacted with each other in the process of developing our understanding of prehistoric life" (Geo 107 Syllabus, Fall Semester, 2001).

When asked about his teaching goals, P_G (personal communication, June 23, 2004) said he was unaware of any; "maybe I don't think about this enough . . . maybe I don't work at it hard enough or think about it enough." Class sizes 100 to 120 students mean he gives few and brief writing assignments, which were used primarily as "rewards for those people who come to class" (P_G, personal communication, June 23, 2004). He said too many long assignments would be "suicide" and he "would be up half the night grading" (P_G, personal communication, June 23, 2004; September 7, 2004). P_G (personal communication, June 23, 2004) revealed his course outcomes and teaching style when he said:

> I'd like them to have an understanding of the way science works and a grasp of the idea that there are historical sciences and physical or non historical sciences. I'm not trying to make scientists out of them. Certainly not. I get after them about saying that scientists try to prove this or prove that because we don't do that. . . . I try to get across the way

science works and keep drilling on the idea rather than make my specific point of it.

He noted that this introductory course was *very similar* to his 500 level introductory paleontology course for geology majors but with less rigorous expectations for bioscience students (P_G, personal communication, June 23, 2004). He explained that offering this course as an introductory bioscience requirement served to fill a gap created when the biology department changed its introductory bioscience focus to molecular biology (P_G, personal communication, June 23, 2004).

Thus, in thinking about both short- and long-term goals and outcomes, participants also identified concerns and barriers that interact with course development and choosing course-appropriate subject areas to present the nature of the geosciences. Before describing participants' subject area choices, concerns and barriers that affect course development are given. Overall, P_G (personal communication, June 23, 2004; September 7, 2004) believed that university administrators were preoccupied with generating student credit hours and with research grant prestige, to the detriment of students. Other concerns and barriers effecting course development and outcomes include large class sizes; low numbers of majors and high numbers of non science majors; student abilities, attitudes, attendance; time and funding constraints.

Concerns and Barriers Effecting Outcomes

Large class sizes were reported by participants to be both a concern and barrier to learning and information outcomes. Before fewer sections and greater students per section became commonplace, L_B (personal communications, July 13, 2004) and AP_E (personal communication, September 7, 2004) spoke of taking students out on field trips. Now, P_G (personal communication, June 23, 2004) and P_F (personal communication, June 18, 2004) give fewer assignments in large enrollment courses because of the time involved in grading. P_G (personal communication, June 23, 2004) said he would never send students in high enrollment classes to read one particular book at the library because "it [the source] would be destroyed by the end of the time they all looked at it." P_G commented further on large class sizes with a story of a colleague at a well known school on the east coast USA remarked that if more than eight students sign up for a class, they open a new section to accommodate the *higher enrollment*.

Participants' showed concern for attracting majors and most participants hoped to persuade a few non majors to become geoscience majors. P_G (personal communication, June 23, 2004) noted there is "pressure to get enrollments up;" he continued with regard to his introductory course, "The course hasn't caught on like we had thought it would" with only 100-120 students per semester. Although this sounded like a reasonable number to this researcher, P_G was at the largest enrollment university, and this number of students did not compare favorably to an introductory earthquake and natural disasters course with 600-700 student enrollment each semester (P_G, personal communication, September 7, 2004). However, P_G's personal web site for his introductory prehistoric life course for bioscience majors states that the course "is a lot of fun to teach and has captured the interest of several students who have decided to major in geology."

At another large enrollment university, P_F (personal communication, June 18, 2004) said, "We'll have one or two majors . . . the majority are taking the class because it fulfills a science requirement and almost no other reason. At a smaller enrollment university, AP_E (personal communication, September 9, 2004) echoed a similar belief, "I'll be lucky to pull in a couple of people into the major."

Participants reported they were not expecting a great number of converts to geoscience; according to some participants, geoscience courses are not as common in K-12 grades as chemistry, biology, and physics. In thinking and planning course goals and expectations, some participants consider the limited background in students' abilities, and understand that this may account for misunderstandings of science. Several participants mentioned that students were ill prepared for thinking scientifically and had limited science background knowledge (AstP_C, personal communication; August 4, 2004; L_B, personal communication, July 13, 2004; AP_E, personal communication, September 9, 2004). "I teach them what the periodic table means again. . . . You can't understand minerals without understanding a little bit about elements" (AP_E, personal communication, September 9, 2004). During lectures AstP_C (personal communication, August 4, 2004) avoids telling students they are talking about chemistry or physics because "that creates a wall." Additionally, AP_E (personal communication, September 9, 2004) noted students were handicapped because they rarely traveled and she was amazed that the majority had not even seen the mountains or other obvious geologic sites in their home states.

Poor student attitudes and attendance were thought to be barriers to learning. L_B (personal communication, September 18, 2004) spoke of the high number of nontraditional students in her classes and believed a fear of science inhibited their progress. AstP_D (personal communication June 18, 2004) reported attendance to be a concern because, "they cannot learn if they are not there." AP_E personal communication, September 9, 2004) said she no longer takes attendance and understands "everybody's life is complicated" and there are valid reasons for missing class; she elaborated on poor attendance:

> I don't control that aspect, it's not my job. My job is to teach and their's is to learn; if they can do the work without coming to class, I don't really care. I find though that's not the correlation.

P_G (personal communication, June 23, 2004) echoed concerns of other participants:

> I don't know why they don't [attend class]. I give weekly tests and they just don't come and they wonder why they do poorly . . . students have a peculiar attitude about attendance and if I get two-thirds of the class some days then that is a good number.

Although the lecture this researcher observed showed P_G was missing less than one-tenth of his enrollment, another observed participant's classroom was missing about one-third of the students who were currently listed on the enrollment roster.

Several participants commented that students' apparent limited background in science and obligation to take a course to satisfy a general science requirement meant they must avoid information overload (AstP_C, personal communication, August 4, 2004; AP_E, personal communication, September 9, 2004; P_F, personal communication, June 18, 2002; P_G, personal communication, June 23, 2004). AstP_C (personal communication, August 4, 2004) remarked, "You can't give beginning students too much detail or they'll just walk away. . . . They don't really need that [overload]."

Other concerns were related to students pushing religious beliefs into a class unrelated to religious studies. Two participants specifically noted disruption in the classroom from creationist believers and that succeeding tensions hampered both teaching and learning (L_B, personal communication, July 13, 2004; AP_E, personal communication, September 9, 2004). AP_E (personal communication, September 9, 2004) described creationists as setting "traps" with comments and questions; and she said now, "I do not talk creationism or intelligent design in class." At the beginning of class, L_B (personal communication, July 13, 2004) said she routinely asks that students set aside personal religious beliefs and attitudes and accept the scientific definitions and concepts presented for the duration of the course.

Time constraints, both work-related and personal, were reported to be negative factors for all participants. AstP_C (personal communication, August 4, 2004) was busy with research and service, but enjoyed teaching an evening session because the 75 minute session allowed for an informal teaching environment and he perceived more could be accomplished as compared with shorter time blocks during the day. GTA_A (personal communication, June 18, 2004) enjoyed the nearly two hour time block for her laboratory course; however, when she took field excursions, it was not enough time to drive to the more interesting geologic sites farther than the immediate region. Also, for GTA_A, her husband was on a tour of duty for the military in Iraq, which further complicated her student and teaching schedules because of their five year old son. According to AP_E (personal communication, September 9, 2004), "There is just not enough time" and she described her rush to place lectures into power point presentations but time constraints prevented her from adding proper citations to the slides then and now. In addition, AP_E (personal communication, September 9, 2004) and P_F (personal communication, June 18, 2004) related that there was little time to devote to the vast number of photographic slides and text figures that needed to be converted into a digital format to be of use in power point or for course web pages. P_G (personal communication, June 23, 2004) said he would update course lectures if his time was not spent on other faculty duties and summed time constraint frustrations when he said, "we are all chasing the 40 hour day."

Funding constraints were reported to create logistical barriers and concerns. AstP_D (personal communication, August 26, 2004) noted a necessity to apply for outside grants to support equipment and student employment for both researching and teaching because there was little if any internal university funding support for their department. P_F (personal communication, June 18, 2004) was concerned for monies from the university to become available so they could advertise for an educator to replace a valuable department faculty member who had left. GTA_A (personal communication, June 18, 2004) was the most forthright about funding barriers when she observed, that added funding is needed to support (a) new faculty and graduate students, (b) the academic library to purchase up-to-date books and stop cutting geoscience journal subscriptions, (c) her laboratory course for replacement specimens, charts, and maps, as well as a computer and power point software for laboratory room, and (d) the purchase of geoscience journal subscriptions specifically for the geology department reading room.

Thus, what emerged from the data were external and cognitive contextual factors, as well as projected and actual information and learning outcomes. External contextual factors were those imposed on participants, where they had little or no control, such as large class sizes and students' abilities, while time and funding constraints were both external and cognitive. Cognitive contextual factors were when participants juggled faculty or student obligations and personal lives with teaching responsibilities. Table 2 summarizes factors reported by participants.

Inquiring into partcipants' personal and course goals and expectations, as well as their background information such as research specialties and career stage, led participants to not only voice concerns with course development but also, to delimit *subject areas* with which they hoped to convey the aspects of their geoscience courses. The interdisciplinary nature of the geosciences is evident when considering subject areas participants said were important to present. Examples from the data follow.

Subject Areas

Generalized subject areas or topics to be covered in a class were given on the course syllabus. In addition to a document review, the researcher asked the participants in interviews to talk about the subjects they wanted to cover and whether or not they consider these topics within or outside the realm of the geosciences. After collecting data on their choices, the researcher provided a listing of 94 researching and teaching specialty areas that are voluntarily provided to AGI by geoscientists and printed in their annual directory (Keane, 2004, p. 275). The interdisciplinary nature of the geosciences is evident when considering subject areas participants said were important to present.

Graduate Teaching Assistant A

GTA_A taught an introductory geology laboratory class that met once a week and included three field trips, two exams, and nine lab activities. She listed subjects

Table 2

Contextual Factors Effecting Course Development and Instruction

Internal-Participant	External-University	External Student
Subject area training	Research expectations	Weak background
Work experience	Service expectations	Negative attitude
Teaching career stage	Student credit hour production	Low attendance
Personal time constraints	Funding constraints	Fear of science
Source convenience	Departmental sources	Preoccupation with
Interpersonal networks	Academic library limitations	creationism

areas covered as mineral identification, including physical properties of minerals; rock identification, including physical rock properties and volcanoes; fossil identification; topographic maps including, latitude and longitude, contour lines, navigation, terrain association, compass orienteering and Global Positioning System (GPS) units; topographic landscapes including, surface weathering and erosion (GTA_A, personal communication, June 18, 2004). Table 3 shows the subject areas GTA_A believed she covered in one semester placed among the published 94 researching and teaching specialty areas (Keane, 2004, p. 275).

GTA_A (personal communication, June 18, 2004) said her approach was a little interdisciplinary. For example, she said, "I do try to bring in the physics. . . . We always get groans and I preface it with I'm sorry but I'm going to have to teach physics a little bit . . . but I try to break it down as basic as possible." In addition to physics, concepts from chemistry and biology are used, as well as practical examples such as campus architecture in order to explain the use of rocks, all areas outside geoscience (GTA_A, personal communication, June 18, 2004).

Lecturer B

L_B taught two courses, Earth Science and the Environment and Oceanography. She identified some of the subject areas and topics covered during the interview as hydrology; anthropology including different societies, hunter gatherer, agriculture, industrial; surface and ground water; pollution; reservoirs for flood control and recreation; pollution across state and international boundaries; plate tectonics, which she called the defining paradigm that brought together problems and unified geology; rock cycle; Earth systems including, lithosphere, pedosphere, atmosphere, biosphere,

Table 3

Subject Areas for GTA_A for Geo 100 "Geology Laboratory"

Subdiscipline	Subject Specialty Areas
Geology	General Geology
	Geomorphology
	Mineralogy
	Igneous, Metamorphic, Sedimentary Petrology
	Sedimentology
	Structural Geology
	Tectonics
	Volcanology
Economic Geology	General Economics
Geochemistry	Geochronology & Radioisotopes
Hydrology	General Hydrology
	Ground water and Hydrogeology
	Surface Waters
	Geohydrology
Paleontology	General Paleontology
	Invertebrate Paleontology
Planetology	Extraterrestrial Geology
Other	Physical Geography

oceans; cosmology; meteorology; Earth history and geologic deep and shallow time, absolute and relative dating; evolution of populations and its affect on environment (L _One, personal communication, July 13, 2004).

L_B (personal communication, July 13, 2004) said concepts from anthropology, biology, chemistry, and environmental studies were outside the geosciences. Specifically, she mentioned topics crossing disciplines as ecology, pollution, hazardous materials, occupational safety & health, and chemical, paper making, food-agriculture industries. Table 4 and 5 show subject areas L_B believed she covered in one semester from the published 94 researching and teaching specialty areas (Keane, 2004, p. 275). She went on to say all environmental studies are interdisciplinary by definition and housed in the geosciences at her university; L_B considered geoscience a good place for environmental studies because bioscience was too narrow of a consideration for the field.

Assistant Professor C

AstP_C taught Understanding Earth and explained in some detail the subject areas he covered during the semester. General topics and subject areas covered were (a) the solar system and physical geology including structure and plate tectonics, (b) structure and composition of the atmosphere, climate and weather evolution, with a focus on the mid latitudes where the students live, (c) biogeography or vegetation distribution and major biomes, which he connects to Earth and atmosphere-climate processes, (d) biogeochemical cycles including nitrogen, carbon, hydrologic, (e) population dynamics, global sustainability, energy use, and the environmental problems that arise from demand for resources and how we extract them, (f) ocean circulations

Table 4

Subject Areas for L_B for Geo 101 "Earth Science and the Environment"

Subdiscipline	Subject Specialty Areas
Geology	General Geology
	Environmental Geology
	Marine Geology
	Petroleum
	Sedimentology
	Tectonics
Economic Geology	General Economics
	Coal
	Metals
	Non metals
	Oil and Gas
Engineering Geology	Petroleum Engineering
Geochemistry	General Geochemistry
	Geochronology & Radioisotopes
Hydrology	General Hydrology
	Ground water and Hydrogeology
	Surface Waters
	Geohydrology

Subdiscipline	Subject Specialty Areas
Oceanography	Biological Oceanography
	Shore and Near Shore Processes
Soil Science	Forest soils, range lands, wetlands
	General Soil Science
	Pedology and Classification Morphology
Other	Physical Geography
	Atmospheric Science
	Earth Science
	Land Use and Urban Geology

Table 5

Subject Areas for L_B for Geo 102 "Oceanography"

Subdiscipline	Subject Specialty Areas
Geology	Geomorphology
	Environmental Geology
	Marine Geology
	Sedimentary Petrology
	Sedimentology
	Tectonics
Geochemistry	Organic Geochemistry
	Marine Geochemistry
Geophysics	Marine Geophysics
Hydrology	General Hydrology
	Surface Waters
Oceanography	General Oceanography
	Biological Oceanography
	Chemical Oceanography
	Geological Oceanography
	Shore and Near Shore Processes
	Physical Oceanography
Other	Physical Geography
	Atmospheric Science

Subdiscipline	Subject Specialty Areas
Other	Earth Science
	Meteorology
	Ocean Engineering and Mining

as it relates to atmosphere, (g) population problems such as global warming or ozone and human interactions with the environment, (h) oil spills and pollution, energy shortage, fossil fuel debate, (i) geochemistry and dating, (j) heat flow from geophysics through solid media, (k) surface waters or hydrology, (l) physical ocean and ocean circulation, and (m) paleo-climate change (AstP_C, personal communication, August 4, 2004). Table 6 sums AstP_C's subject areas according to geoscience specialty areas (Keane, 2004, p. 275).

AstP_C (personal communication, December 3, 2004) said his course, field of study, as well as geoscience are obviously interdisciplinary. He is an "atmospheric scientist and an interdisciplinary scholar, who works at the intersection of atmosphere, hydrosphere, and top few layers of the lithosphere, and how this impacts and is impacted by people" (AstP_C, personal communication, December 3, 2004). He went on to say his "training is in the disciplines that intersect geography, remote sensing, geographic information systems (GIS), and hydrology." This allows AstP_C (personal communication, December 3, 2004) "to choose a topic to work on and apply his specialty to that topic, which creates a hybrid discipline." For example, he is interested in "ozone development or ozone formation in cities because it relates to my specialty of heat loading associated with land use changes within cities and this is what drives the chemical reaction that produces the ozone" (AstP_C, personal communication, December 3, 2004). AstP_C believed "geoscience finds its best focus as an interdisciplinary science; and although plate tectonics serves as the unifying theory in geology, the geosciences are interdisciplinary and cannot have one unifying theory."

Table 6

Subject Areas for AstP_C for Geo 103 "Understanding Earth"

Subdiscipline	Subject Specialty Areas
Geology	General Geology
	Geomorphology
	Marine Geology
	Structural Geology
	Tectonics
	Volcanology
Economic Geology	General Economics
	Coal
	Metals
	Oil and Gas
Engineering Geology	Earthquake Engineering
Geochemistry	General Geochemistry
	Geochronology & Radioisotopes
	Marine Geochemistry
Geophysics	Heat Flow
Hydrology	General Hydrology
	Ground water and Hydrogeology
	Surface Waters
Oceanography	Biological Oceanography

Subdiscipline	Subject Specialty Areas
Oceanography	Chemical Oceanography
	General Oceanography
	Physical Oceanography
Paleontology	Paleoecology and Paleoclimatology
Planetology	Extraterrestrial Geology
Soil Science	Forest soils, range lands, wetlands
Other	Physical Geography
	Atmospheric Science
	Earth Science
	Meteorology
	Geographic Information Systems
	Remote Sensing
	Land Use and Urban Geology

Assistant Professor D

AstP_D (personal communication, June 18, 2004) taught a physical geology course, Earth in Action, and explained during the interview that the broad subject areas covered were plate tectonics; Earth systems; minerals; rocks; geotime; geostructures; surface processes; earthquakes; volcanoes; and Earth resources. Specific information in Table 7 shows the subject areas according to geoscience specialty areas (Keane, 2004, p. 275). AstP_D (personal communication, August 26, 2004) said her course was definitely interdisciplinary because physics concepts were essential to explain earthquake action; economics were brought into discussion of earthquake damage to property and landscapes; and business and political policy were discussed when examining a country's wealth of natural resources.

Associate Professor E

AP_E (personal communication, September 9, 2004) taught Geo 105 General Geology and listed some of the subject areas covered during the interview as ground water; general paleontology; geologic time; extraterrestrial geology, including the formation of Earth; Earth's interior; stable isotopes for carbon, C12 and C13; environmental geology such as lead paint or asbestos; rocks in general and not in thin section. Table 8 shows AP_E's subject areas covered during a semester according to AP_E (personal communication, December 3, 2004) asserted that "geology is interdisciplinary" and said that does not mean "glacial geologists talking to a petrologist because that is within the discipline of geology," rather:

> Interdisciplinary is geology and history, geology and archaeology, or geology and economics. It is physics, math, and chemistry applied to

Table 7

Subject Areas AstP_D for Geo 104 "Earth in Action"

Subdiscipline	Subject Specialty Areas
Geology	General Geology
	Environmental Geology
	Geomorphology
	History of Geology
	Marine Geology
	Mineralogy
	Igneous, Metamorphic, Sedimentary Petrology
	Sedimentology
	Structural Geology
	Tectonics
	Volcanology
Economic Geology	General Economics
	Coal
	Metals
	Non metals
	Oil and Gas
Engineering Geology	Earthquake Engineering
Geochemistry	Geochronology & Radioisotopes
Geophysics	General Geophysics

Subdiscipline	Subject Specialty Areas
Geophysics	Gravity
Geophysics	Seismology
Hydrology	General Hydrology
	Ground water and Hydrogeology
	Surface Waters
Oceanography	Geological Oceanography
	Shore and Near Shore Processes
Planetology	Extraterrestrial Geology
	Extraterrestrial Geophysics
Other	Atmospheric Science
	Material Science
	Land Use and Urban Geology

Table 8

Subject Areas AP_E for Geo 105 "General Geology"

Subdiscipline	Subject Specialty Areas
Geology	General Geology
	Environmental Geology
	Geomorphology
	Glacial Geology
	Marine Geology
	Petroleum Geology
	Mineralogy
	Igneous Petrology
	Sedimentology
	Tectonics
	Volcanology
Economic Geology	Metals
	Non metals
	Oil and Gas
Engineering Geology	Mining Technology and Extractive
Geochemistry	Geochronology & Radioisotopes
	Stable Isotopes
Geophysics	Seismology
	Geomagnetism and Paleomagnetism

Subdiscipline	Subject Specialty Areas
Hydrology	General Hydrology
	Ground water and Hydrogeology
	Surface Waters
Oceanography	General Oceanography
Paleontology	General Paleontology
Soil Science	General Soil Science
Planetology	Extraterrestrial Geology

> geology problems. Other areas of interest may be minerals and chemistry, earthquakes and physics, economics and ore deposits, flood control and environment, asbestos or lead hazards and political science.

She said everything is geoscience and that, "Our lives are intimately related to the geosciences. We wouldn't have walls to buildings without an understanding of geoscience." In terms of the health, economic, and political related geoscience issues, "I tell them they have a vote and we want to help create an informed citizenry" (AP_E, personal communication, December 3, 2004).

Professor F

P_F (personal communication, June 18, 2004) taught a physical geology course, “Earth in Action,” and itemized subject areas covered in a semester including Earth’s interior; plate tectonics; Earth's resources or what we get from Earth that is geologic and has some meaning to your life. She continued, "these topics sort of set the stage for why we go in and cover all the other things" such as time scale and dating-absolute and relative; cross section interpretation; Earth as a system; origins of the solar system and temporal context to distance in a Big Bang like event; soils and weathering; glaciers, deserts, and earthquakes. Special emphasis is given to the rock cycle, and P_F (personal communication, June 18, 2004) explained the rock cycle:

> In terms of rocks and minerals and if we intrude magma and cool it or extrude it, form an igneous rock and what happens next? Well then it weathers and it breaks down and those different pieces end up somewhere and that's how we get sediment.

Subjects not cover include paleontology, oceanography, meteorology, or astronomy because these are covered in other introductory courses. Regarding interdisciplinarity and the topics that rely on disciplines outside geoscience, P_F (personal communication, June 18, 2004) said:

> To some extent we talk about physics and chemistry with minerals but not too heavy into details because we are restricted by the audience of non science majors. We talk about human impact of earthquakes, mass wasting, ground water, and other topics that effect humans; we talk about Earth resources and how it drives foreign policy and what we are doing good and bad in this country with resources. We talk about the state's resources, limestone, sand, and gypsum, which are heavy into building, so yes [her course content is interdisciplinary].

Table 9 shows P_F's subject areas covered during a semester according to geoscience specialty areas (Keane, 2004, p. 275).

Professor G

P_G (personal communication, June 23, 2004) taught a Geo 107 “Prehistoric Life” course and explained during the interview topics and subject areas covered were geochronology; paleostratigraphy, rocks and fossils; not strictly geobiology, which is microbial, but some on microbes in Protozoic events; invertebrate, micropaleontology, and vertebrate paleontology; fossil and fossil record; geologic time; rocks; plate tectonics; evolutionary theory and extinctions; organizing life and the Linnean system; classification schemes; functional morphology; "trudge through time" from Precambrian life, Cambrian explosion, and present, including fishes, amphibians,

Table 9

Subject Areas for P_F for Geo 106 "Earth in Action"

Subdiscipline	Subject Specialty Areas
Geology	General Geology
	Environmental Geology
	Geomorphology
	Glacial Geology
	Marine Geology
	Petroleum Geology
	Mineralogy
	Igneous Petrology
	Sedimentology
	Tectonics
	Volcanology
Economic Geology	Metals
	Non metals
	Oil and Gas
Engineering Geology	Mining Technology and Extractive
Geochemistry	Geochronology & Radioisotopes
	Stable Isotopes
Geophysics	Seismology
	Geomagnetism and Paleomagnetism

Subdiscipline	Subject Specialty Areas
Hydrology	General Hydrology
	Ground water and Hydrogeology
	Surface Waters
Oceanography	General Oceanography
Paleontology	General Paleontology
Soil Science	General Soil Science
Planetology	Extraterrestrial Geology

plants, insects, dinosaurs, mammals, whale and horse evolution, birds and mammals, human evolution; and what's this all about or an epilogue. His file folders created for images were succinctly named: introduction; history of science; fossils in time; fossil record; history of ideas; phyllums and kingdoms; rocks and fossils; taphonomy; systematics; introduction to evolution; macro evolution; micro evolution and functional morphology; hederochrony; invasion of the land, plants and insects; human evolution; cartoons; famous people. With regard to interdisciplinarity and his course, P_G (personal communication, June 23, 2004) said, "Oh I suppose you'd have to say that because it includes both biology and geology; but on the other hand, if you think of it as paleontology it's not interdisciplinary unless the acceptance of science itself is interdisciplinary." Table 10 shows subject areas covered during a semester according to geoscience specialty areas (Keane, 2004, p. 275).

Summary

In summary, Table 11 shows each course and the subdisciplines of geoscience covered according to the classification by Keane (2004, p. 275). Each of the courses included broad subject areas within three to eleven subdisciplines. Concepts covered from disciplines other than ones considered subdisciplines of geoscience include anthropology, biology, physics, chemistry, economics, political science, business, and environmental studies. “Prehistoric Life” was the most specialized, including concepts from geology, geochemistry, and paleontology subdisciplines. Other specialized courses, “Geology Laboratory” and “Oceanography” included only eight subdisciplines; while “Understanding Earth” was the least specialized and incorporated subject area

Table 10

Subject Areas for P_F for Geo 107 "Prehistoric Life"

Subdiscipline	Subject Specialty Areas
Geology	General Geology
	History of Geology
	Sedimentary Petrology
	Stratigraphy
	Tectonics
Geochemistry	Geochronology & Radioisotopes
Paleontology	General Paleontology
	Paleostratigraphy
	Geobiology
	Invertebrate Paleontology
	Micropaleontology
	Paleobiology
	Paleobotany
	Paleoecology and Paleoclimatology
	Vertebrate Paleontology

Table 11

Summary of Geoscience Subdisciplines per Course

Subdiscipline	100	101	102	103	104	105	106	107
Geology	X	X	X	X	X	X	X	X
Economic Geology	X	X		X	X	X	X	
Engineering Geo		X	X	X	X	X	X	
Geochemistry	X	X	X	X	X	X	X	X
Geophysics			X	X	X	X	X	
Hydrology	X	X	X	X	X	X	X	
Oceanography		X	X	X	X	X	X	
Paleontology	X			X		X	X	X
Planetology	X			X	X	X	X	
Soil Science		X		X	X	X	X	
Other Subdisciplines	X	X	X	X	X			
Other Disciplines	X	X	X	X	X	X	X	X

concepts in each subdiscipline of the geosciences. Geology and hydrology are the subdisciplines utilized most often.

Table 12 shows each of the subject areas within geology, a subdiscipline of geoscience. The subject area that every participant incorporated into their course was tectonics or specifically, plate tectonics, the unifying theoretical framework for geology (Thagard, 1992, p. 157). The subject area used the least was history of geology, used by physical geology and paleontology courses.

Table 13 shows each of the subject areas within economic geology, a subdiscipline of geoscience. Partcipants teaching Oceanography and Prehistoric Life did not incorporate any economic geology subjects into their courses; while the geology lab course included only general economic category. Other courses were more inclusive of economic geology topics.

Table 14 shows subject areas within engineering geology. Partcipants teaching "Oceanography," "Prehistoric Life," and "Earth and the Environment" did not incorporate any engineering geology subjects, while others use earthquake engineering in courses.

Table 15 shows each of the subject areas within geochemistry. All courses except for "Oceanography" incorporate geochronology and radioisotopes into their courses. "Understanding Earth" and "Oceanography" include marine oceanography subjects.

Table 16 shows each of the subject areas within geophysics, a subdiscipline of geoscience. All courses except for "Earth Science" and "Prehistoric Life" have some component of geophysics. The physical geology courses all use seismology.

Table 12

Summary of Subject Areas in Geology per Course

Subdiscipline	100	101	102	103	104	105	106	107
Environmental Geo		X	X		X	X	X	
General Geology	X	X		X	X	X	X	X
Geomorphology		X	X	X	X	X	X	
Glacial Geology	X					X	X	
History of Geology					X			X
Marine Geology		X	X	X	X	X		
Mineralogy	X				X	X	X	
Petroleum Geology		X		X		X		
Igneous Petrology	X			X	X	X	X	
Metamorphic Petro.	X				X		X	
Sedimentary Petro.	X				X		X	X
Sedimentology	X	X	X		X	X	X	
Stratigraphy							X	X
Structural Geology	X			X	X		X	X
Tectonics	X	X	X	X	X	X	X	X
Volcanology	X			X	X	X	X	

Table 13

Summary of Subject Areas in Economic Geology per Course

Subdiscipline	100	101	102	103	104	105	106	107
General Geology	X	X		X	X		X	
Coal	X			X	X		X	
Metals	X			X	X	X	X	
Non metals	X				X	X	X	
Oil and Gas	X			X	X	X	X	

Table 14

Summary of Subject Areas in Engineering per Course

Subdiscipline	100	101	102	103	104	105	106	107
Earthquake Engineering				X	X	X		
Mining Technology/Extractive						X		
Petroleum Engineering		X						

Table 15

Summary of Subject Areas in Geochemistry per Course

Subdiscipline	100	101	102	103	104	105	106	107
General Geochem.	X			X				
Geochronology/Rad.	X	X		X	X	X	X	X
Marine Geochem.			X	X				
Organic Geochem.	X							

Table 16

Summary of Subject Areas in Geophysics per Course

Subdiscipline	100	101	102	103	104	105	106	107
General Geophys.					X			
Geomagnetism/Paleo.						X		
Gravity		X						
Heat Flow				X				
Seismology					X	X	X	
Marine Geophys.			X					

Table 17 shows each of the subject areas within hydrology, a subdiscipline of geoscience. All courses except for "Prehistoric Life" rely on the subject categories of hydrology, and all participants incorporate subjects dealing with surface water. Hydrology is a general term for the study of water in any environment, while hydrogeology is specific to subsurface water and interaction between surface and subsurface water.

Table 18 shows each of the subject areas within oceanography, a subdiscipline of geoscience. "Prehistoric Life" and "Geology Laboratory" do not contain oceanography topics, while oceanography obviously utilizes all categories. "Understanding Earth" utilizes most of the categories, while physical geology course use one or two components of oceanography.

Table 19 shows each of the subject areas within paleontology, a subdiscipline of geoscience. Obviously, "Prehistoric Life" contains nearly all components of this field.

Table 20 shows each of the subject areas within planetology, a subdiscipline of geoscience. "Prehistoric Life" does not use planetology topics, while all other courses cover extraterrestrial geology, commonly explained as formation of moon, Mars, etc.

Table 21 shows each of the subject areas within soil science. While the "Earth Science and Environment" course depends upon soils, "Prehistoric Life," "Oceanography," "Geology Lab," and one "Physical Geology" courses do not incorporate soil science at all. Two other physical geology courses briefly cover soils in general, and "Understanding Earth" course includes subjects within wetlands and forest/range land soils.

Table 17

Summary of Subject Areas in Hydrology per Course

Subdiscipline	100	101	102	103	104	105	106	107
General Hydrology	X	X	X	X	X	X		
Ground water/ hydrogeology	X	X		X	X	X	X	
Surface Waters	X	X	X	X	X	X	X	
Geohydrology	X	X						

Table 18

Summary of Subject Areas in Oceanography per Course

Subdiscipline	100	101	102	103	104	105	106	107
General Oceanography			X	X		X	X	
Chemical Oceanography			X	X				
Biological Ocean.	X		X	X				
Geological Oceanography			X		X			
Physical Oceanography			X	X				
Shore/Near Shore Processes	X		X		X			

Table 19

Summary of Subject Areas in Paleontology per Course

Subdiscipline	100	101	102	103	104	105	106	107
Paleostratigraphy								X
General Paleontology		X				X	X	X
Geobiology								X
Invertebrate Paleontology		X						X
Micropaleontology							X	X
Paleobiology								X
Paleobotany								X
Vertebrate Paleontology								X
Paleoecology & Paleoclimatology				X				X

Table 20

Summary of Subject Areas in Planetology per Course

Subdiscipline	100	101	102	103	104	105	106	107
Cosmochemistry	X		X					
Extraterrestrial Geo.	X	X	X	X	X	X	X	
Extrater. Geophysics	X	X	X					
Meteorites/tektites	X		X					

Table 21

Summary of Subject Areas in Soil Science per Course

Subdiscipline	100	101	102	103	104	105	106	107
General Soil Science		X				X	X	
Forest soils, range-								
Land, wetland		X						
Pedology/classification		X						
Soil biology/biochem.		X						
Soil physics/hydrology		X						

Table 22 shows each of the subject areas from other topics within geoscience. Some choices of subject areas to present may be based on the participant's research specialty areas, which are used as examples or applications of concepts. For example, the participant who teaches Geo 107 is an atmospheric scientist who researches urban land use and meteorology, utilizing remotely sensed data and geographic information systems software, which are all topics he found important for course development or instruction.

Thus, what has emerged from the data is that developing course and instruction begins with identifying goals and expectations, followed by thinking about subject areas and topics. P_G (personal communication, September 7, 2004) explained course planning, "my view would be that. . . you develop ideas about what you think the course should be about and then you hunt for a textbook that is pretty close . . . you use your personal experience to talk about those topics and the textbook to bolster if it will do so." Based on participants' background information, including research specialties and former school and employment training, it is obvious that personal experience will guide participants to choose certain subject areas with lectures and activities based on intrapersonal knowledge and personal resources. However, choosing the appropriate textbook and preparing for less familiar subject areas and topics identifies information needs and information seeking from external sources, or sources other than self, in order to create activities or illustrate concepts. Results from questions on information needs and strategies to support teaching follow.

Table 22

Summary of Subject Areas in Other within Geoscience per Course

Subdiscipline	100	101	102	103	104	105	106	107
Atmospheric Science	X	X	X	X	X		X	
Earth Science	X		X	X				
Physical Geography	X	X	X	X				
Land Use/Urban Geo.	X		X	X	X			
Geographic Info Systems				X				
Material Science		X			X		X	
Meteorology	X		X	X				
Ocean Engineering/Mining			X					
Remote Sensing				X				

Information Needs of Geoscience Participants

What emerged from the data in this study is that while geoscience participants noted topics and subject areas they wanted to communicate with students, information needs were recognized and discussed. Information needs arise when knowledge is insufficient to satisfy goals. Information needs are satisfied with a combination of formal and informal information sources and tools to inform self and others. In addition to sources, various physical and electronic media were reported to enhance course delivery and instruction, including and beyond the traditional lecture and chalkboard.

Information needs satisfied with informal information sources refer to intrapersonal or interpersonal, self or person-to-person relations; while needs satisfied with formal information sources refer to published literature and unpublished documentation and raw data (Allen, 1993, p. 293). Adopting Allen's interpretations for this research, informal sources are the participant's personal experiences and knowledge, as well as interactions with colleagues, students, and vendors in both a face-to-face or electronic exchange. In contrast, formal sources were reported to act to supplement informal sources, and whether published or unpublished, they are tangible materials including text and images in journals and books. Data from this research showed formal sources external to the participant to include maps; ground, aerial, and satellite photographs and images; geophysical well logs; seismograms; meteorological records; rock, mineral, and fossil specimens; field trip guidebooks; brochures; and open-file reports for the public domain in governmental agencies. Data from this research showed formal sources internal to the participant, and mostly unpublished, include personal lecture notes; photographic pictures, slides or digital images;

transparencies for overhead projection; drawings; course web pages; and electronic presentations such as power point presentations for lectures or professional association meetings.

Thus, various traditional and innovative ways of exchanging and obtaining information needed by geoscience participants to cover projected subject areas, shown in the previous section, emerged from the data. As might be expected informal intrapersonal knowledge is heavily relied upon with participants; however, intrapersonal knowledge is supplemented with informal interpersonal information and formal unpublished and published sources as well. Academic training and previous work experience qualify these participants to write or go beyond a given textbook for course development and delivery and to create effective instructional techniques and demonstrations to illustrate subject areas and concepts. Participants' accounts of their information needs and concerns to support teaching follow.

Identifying Information Needs

Graduate Teaching Assistant A

In her current position teaching and training other students to teach an established geology laboratory course, GTA_A satisfies information needs primarily through intrapersonal knowledge and unpublished formal sources. GTA_A's (personal communication, June 18, 2004) former faculty mentor realized a commercial textbook based on her projected information outcomes, current department resources, and available regional geology did not exist. Hence, she obtained an external grant to purchase materials and support students, such as GTA_A, to aid in creating a custom textbook, teaching notebook, and field-trip guidebook. The teaching notebook, available for any students teaching the course, contains handout originals and transparencies; that is, in addition to the chalkboard, an overhead projector and screen are used to display illustrations on transparencies. The room is designed to hold up to 24 students and is equipped with field tools such as compass and GPS units, as well as formal information sources used in teaching such as maps, posters, and mineral, rock, and fossil specimens.

Therefore, GTA_A relies upon the geoscience department sources and training provided by her former instructor and mentor, who specialized in geoscience education. Her intrapersonal knowledge was gained from recent undergraduate degrees in both geology and education, as well as past work experience in the military (GTA_A, personal communication, June 18, 2004). For example, she attended a geology field course on the Hawaiian Islands in July and was eager to share her island maps, volcanic rock samples, photographs, and new knowledge in September for the lecture on igneous rock and volcanoes (GTA_A, personal communication, August 26, 2004). In the class session this researcher observed, GTA_A introduced subjects showing figures on transparencies and using words to create images. For instance, she showed a transparency of plate tectonic boundaries and when explaining concepts, such as waves of energy moving through solid rock layers created from movement in the Earth, she spoke of the frequent earthquakes where she grew up in California as *roller coaster* rides (GTA_A, personal communication, August 26, 2004). In other examples, when introducing mineral properties, students had in their hands the mineral sphalerite and GTA_A said because this mineral had sulfur in it, "streaking sphalerite smells like rotten egg;" she went on to say if everyone scratches it on their streak plates at the same time, they will have to open the windows, which gave students a humorous point of reference to remember sphalerite (GTA_A, personal communication, August 26, 2004). In explaining properties and processes, she alluded to the use of other disciplines. For instance, she described how and why minerals break in characteristic ways, and added, but "I don't want to scare you with chemistry" (GTA_A, personal communication, August 26, 2004).

Assignments are completed within class time and no outside activities are given to students. However, she challenged the students to see *The Core*, a popular fictional movie with a geologic theme, and to note the accuracy of the portrayal of Earth's interior and processes based on what they have learned in class (GTA_A, personal communication, August 26, 2004).

Because the course was established, information needs were less evident; GTA_A said if she needed information for the laboratory course, then she would contact her former mentor or the current geoscience faculty (GTA_A, personal communication, June 18, 2004; August 26, 2004). She described the geoscience faculty as "laid back, self-sufficient," having an open door policy for students, and sharing freely of resources and time (GTA_A, personal communication, June 18, 2004). Thus, she would turn to interpersonal information sources, geology faculty because "they speak the same language" (GTA_A, personal communication, August 26, 2004).
A listing of instructional enhancing media and information sources used to enhance teaching was created from interviews, documents, and observations. Instructional enhancing media use is summarized Table 30. Table 23 shows the formal and informal sources GTA_A actually uses to enhance and ones wished for. However, she reported that she uses print photographs, but wished for the needed hardware and

Table 23

Sources to Enhance "Geology Laboratory" GTA_A

Sources	Used	Wished For
Maps	X	
Globe	X	
Field Trip Guidebook	X	
Reference & Textbooks	X	X
Journals		X
Rock & Mineral Specimens	X	X
Fossil Specimens	X	
Transparencies	X	X
Photographs	X	
Digital Images		X
Figure/Animation/Cartoon	X	X
Power Point Slides		X
Seismic Software		X
Internet Websites	X	X
Demonstrations	X	
Hallway Displays	X	
Field Trips	X	
Colleagues	X	

software to create and show power point slides with digital images to support lectures. Also, she was interested in *The Journal of Geological Education*. An example of a demonstration for GTA_A was physically showing a mineral's reaction acid on the mineral's surface.

Lecturer B

L_B satisfies information needs through intrapersonal knowledge and formal, unpublished and published sources, yet she would welcome interpersonal exchange with colleagues if her schedule permitted. L_B is the only participant teaching a telecourse. This mode of teaching means she arranges assignments for students to accomplish outside of class and mainly comes to campus eight Saturdays a semester to meet the classes. In order to communicate with students, she encourages them to contact her via email and to visit the online Blackboard system dedicated to their class where they check their assignments, grades, and meeting times of the eight face-to-face class sessions (L_B, personal communication, July 13, 2004). L_B requires students to obtain audio-visual sources and textbook; the textbooks have accompanying publisher's websites with self-tests, study guides, and study questions (Geo 101 & Geo 102 Syllabi, fall semester, 2004). Audio-visual sources are videos that may be rented from the campus bookstore, accessed on reserve at the academic library, or viewed and taped off a scheduled broadcast from the local campus television station (Geo 101 & Geo 102 Syllabi, fall semester 2004).

It is important to L_B that audio-visual sources illustrate concepts compatible with textbook chapters and be age appropriate. Although there is a well integrated program, including video series, text, and study guide, appropriate for the oceanography course, there is no commercial coordinated program for her second course, Earth Science and the Environment, which is a course with an interdisciplinary approach (L_B, personal communication, July 13, 2004). L_B has a need for pertinent, up-to-date audio-visual sources and she wished for help in awareness, acquisition, and funding of these sources (L_B, personal communication, July 13, 2004). During one semester, each course has 26 one hour broadcast episodes (Geo 101 & Geo 102 Syllabi, fall semester, 2004).

Lectures, discussions, demonstrations, activities, and tests occur during in-class two hour meetings. She stressed the importance of class attendance and missing a class means missing a quiz, which can be made up at the campus testing center at a cost of $8.00 per quiz (Geo 101 & Geo 102 Syllabi, fall semester, 2004). L_B organized a field trip for a class of seventy her first semester of teaching at this university, but did not repeat the experience because of the complications and consequences of the large class size and infrequent face-to-face meetings. Thus, she creates class demonstrations and activities to explain concepts, and she uses specimens of rocks, minerals, and fossils, as well as maps and stereo pair air photos, which are viewed using a stereoscope or special glasses that create a sense of depth and 3-dimensional view of landscape (L_B, personal communication, July 13, 2004). Among the course assignments are media reports where students choose a geoscience or oceanographic event that has human consequences to write about according to L_B's criteria; she encourages use of newspapers, news websites, television news, popular magazines, or scholarly journals (L_B, personal communication, July 13, 2004). The most used sources are websites and the least used, scholarly journals (L_B, personal communication, July 13, 2004).

During the classroom observation, L_B collected media report assignments and used one as a way to generate discussion and encourage sense-making among students. For example, the media report was on the rising price of oil; she related that in years past, oil seeped onto the surface on her ranch property, but no new wells were drilled because of the $12-$13 price per barrel. However, the student reported the current $40 price per barrel. Discussion followed on the relationship to gasoline prices and political stability of countries with oil and those without. Throughout the lecture, she tried to engage the students and brought in her personal experiences to serve as examples.

Unfortunately, the campus meeting room was lacking in comfort and instructional enhancing media. A moldy smell in the room meant opening the outside door, which created noise and a draft and students avoided sitting near the door (L_B, personal communication, September 18, 2004). The room held over one hundred and had comfortable chairs with a sloped floor in a theatre-like configuration so the instructor was clearly visible (L_B, personal communication, September 18, 2004). While her voice projected well to the back of the room, the instructional media did not project as well; the room was equipped with a chalkboard behind a long bench table, a small screen and overhead projector (L_B, personal communication, September 18, 2004). She read the transparencies, provided handouts, and wrote and sketched boldly on the board in white and colored chalk. Even though she passed individual rock samples around the room, there were many students in the room and the last to see the sample may have forgotten its significance (L_B, personal communication, September 18, 2004). She had students come to the front of the room to participate in demonstrations, and she showed cartoons to add humor and concept understanding (personal communication. September 18, 2004).

While instructional enhancing media use is summarized Table 30, Table 24 shows sources used and wished for to enhance teaching unique to L_B. For example, she checked the use of print photos but wished for digital images and needed equipment in the lecture room to use power point slide presentations.

Assistant Professor C

AstP_C depends on intrapersonal and interpersonal knowledge and information, along with formal published and unpublished information sources to support teaching. AstP_C has an active research agenda that generates examples to use in his classes; within the geoscience department, AstP_C spoke of sharing among colleagues, lecture notes and sources such as slides and digital images (AstP_C, personal communication, September 21, 2004). In addition, AstP_C calls himself an interdisciplinary scholar and as such satisfies information needs with his own experiences combined with his collaborators' experiences (AstP_C, personal communication, December 3, 2004). He views teaching in the same way, in that student learning is collaborative. Outside of the university, AstP_C is a recipient of a NASA Earth System Science Education (ESSE 21) grant, and this affiliation allows him enhanced access to interpersonal information, formal sources including data, from the granting agency and the Digital Library of Earth System Education (AstP_C, personal communication, August 4, 2004). He has opportunities through an affiliation with his post doctorate university; for example, he receives daily satellite weather-related data from a national research center (AstP_C, personal communication, September 21, 2004). Although much of this information and

Table 24

Sources to Enhance "Earth Science & Environment" & "Oceanography" L_B

Sources	Used	Wished For
Maps	X	
Globe	X	
Reference & Textbooks	X	X
Journals		X
Reprints/Preprints	X	
Rock & Mineral Specimens	X	
Fossil Specimens	X	
Transparencies	X	
Photographs	X	
Digital Images		X
Figure/Animation/Cartoon	X	X
Power Point Slides		X
Aerial photo stereo pair	X	
Meteorological records		X
Internet Websites	X	X
Demonstrations	X	
Video/DVD/TV broadcast	X	X
Museum	X	
Colleagues	X	X

data from university research centers and government sponsored websites are used for research and upper level course, some sources are used for his introductory course such as NASA sponsored graphics and animations depicting plate tectonics and Corollas effects (AstP_C, personal communication, August 4, 2004). He stressed the importance of using visuals, graphics and animations, to aid in student understanding of important concepts (AstP_C, personal communication, August 4, 2004).

The course textbook is supplemented with a CD but AstP_C believes it is not all useful (AstP_C, personal communication, August 4, 2004). However, the textbook publisher has materials online for teacher and student access. For instance, he has students take the customized tests online, which he creates from the publishers bank of questions, and the results are emailed directly to him (AstP_C, personal communication, August 4, 2004). Thus, the textbook and accompanying website are useful, but to develop some subject areas he investigates topics of local interest that students can see first hand. AstP_C encourages students to bring in "their own experiences to bear on the topic" (AstP_C, personal communication, August 4, 2004). For instance, when talking about water, the environment and environmental processes, AstP_C uses rivers that flow through the urban area as examples; he emphasized the impact one major river has on the city through flooding, transportation, water use, and dams or other actions by the Corps of Engineers (AstP_C, personal communication, August 4, 2004). He purchased a set of slides, and he borrowed video materials on the river from the public library, because these sources were not available at the academic library (AstP_C, personal communication, August 4, 2004).

Another subject area, petroleum geology, is developed in an activity called "to drill or not to drill," which covers oil, gas, and coal through class debates where students are assigned to take sides on the issue in a local or global instance, gather the background and present (AstP_C, personal communication, August 4, 2004). Also, he creates activities in class using the Internet connection available in the classroom. "Local weather stations have live weather reports on web sites" and AstP_C brings up the website during lecture in order to discuss the significance of "pressure systems across the US" (AstP_C, personal communication, September 21, 2004).

One assignment, Current Events Synthesis papers, asks students to find news articles about an environmental issue and write a synthesis paper on the topic. His point is to learn content but more importantly, to learn about appropriate sources for good scientific information (Geo 103 Syllabus, Fall semester, 2004; AstP_C, personal communication, September 21, 2004). At the end of the semester, he praised the students' efforts but voiced frustration with some students' choices of sources; although his expectations were not explicit on the syllabus, he was expecting peer reviewed journals as opposed to open file government reports when they expanded their topic for the synthesis paper (AstP_C, personal communication, December 3, 2004). During the last interview, he said he has gained an awareness of the role of academic library and librarian from my research study, and in the future he would invite a librarian to his class to discuss appropriate sources and what the academic library had to aid students (AstP_C, personal communication, December 3, 2004).

Table 25 show instructional enhancing media and information sources that are unique to AstP_C. For example, he was aware of the clicker devices offered through publishers accompanying textbooks and was considering this way in the future.

Assistant Professor D

AstP_D was the only participant to openly post lecture materials online without the password protection of a Blackboard or WebCT system. At her course website, there is a link to the syllabus, daily schedule, sources, past quizzes, past exams, grading scale, lecture figures, and the textbook publishers website, which contains many student help links including animations, flashcards, quizzes, concept-self checker, and a how to study geology page. She posts homework assignments and after collected, the answers are posted online as well (AstP_D, email communication, June 18, 2004).

To satisfy course related information needs, AstP_D relies on intrapersonal and interpersonal knowledge and information, as well as formal published sources that are gathered primarily through Internet sites. During lectures, she refers to her current and past research, as well as other research conducted with colleagues, including her husband. For instance, she talks about the enhanced damage caused by a California earthquake, which was her dissertation; also, she talks about results of a seismic experiment conducted near to the university, which was funded through a National Science Foundation grant written by several colleagues including her and her husband (AstP_D, personal communication, June 18, 2004). AstP_D depends on electronic sources such as websites from the textbook publisher, Digital Library for Earth System Science Education (DLESE), other universities, state and federal government surveys,

Table 25

Sources to Enhance "Understanding Earth" AstP_C

Sources	Used	Wished For
Maps	X	
Globe	X	
Reference & Textbooks	X	
Journals	X	
Photo Slides	X	
Digital Images		
Figure/Animation/Cartoon	X	
Power Point Slides	X	
Meteorological records	X	
Internet Real-time data	X	
Internet Websites	X	
Demonstrations	X	
Museum	X	
Video/DVDs	X	
Colleagues	X	

online journals such as *Science* and *Nature* (AstP_D, personal communication, August 27, 2004). Online websites provide new or background materials for her courses by giving access to downloadable data and software; activities and demonstrations; animations, illustrations, and figures (AstP_D, personal communication, August 27, 2004). One student homework assignment involves downloading virtual simulation software, and the student must locate the "focal location and magnitude of a virtual earthquake;" awareness of and access to this simulation software is by way of the university she attended for graduate work (AstP_D, personal communication, June 18, 2004).

In lectures, AstP_D uses local and regional geologic features as examples and applications of the geosciences. Instead of physically taking one hundred students out in the field, she brings into class photographs, digital images, specimens, and maps to visually take them into the field classroom demonstrations and activities illustrate geologic processes (AstP_D, personal communication, June 18, 2004). For example, to show mechanical or physical weathering of rock she uses two-liter plastic soda bottles with limestone pebbles and water; she asks the students to shake their bottle vigorously and observe what results occur over the lecture time; she discusses what they observed and the geologic processes it represents at the end of the lecture (AstP_D, personal communication, June 18, 2004). An activity to show geologic time involves the use of a jump rope and clothespins; the jump rope-time line is the beginning of Earth at one end and present time at the other and clothespins are to be placed at major geologic time periods. After showing where the pins should have been placed, students see relatively, the billions of years for the planet to evolve and the brief existence of human evolution on Earth (AstP_D, personal communication, June 18, 2004).

AstP_D's greatest information need is to find more illustrations, animations, or figures, and demonstration and activity ideas to visually explain difficult concepts to the students (AstP_D, personal communication August 27, 2004). She goes online using the Google search engine or electronically visits her local academic library e-database as a pointer to sources (AstP_D, personal communication, August 26, 2004). AstP_C acquires some animations and video clips from educational websites and textbook publisher websites (AstP_D, personal communication August 26, 2004). AstP_D has developed many classroom demonstrations on her own because she has taught a number of years, yet she looks to textbooks and other reference books for new ideas as well (AstP_D, personal communication, August 26, 2004).

The lecture room held over one hundred students and seating was on a sloped floor for an easy view of the instructor at the front of the room. An enormous screen could be lowered over a chalkboard that lined one wall of the room. AstP_D used power point slides with text and animation, as well as the ELMO projection system to write out an outline of what she was saying or to sketch a diagram; this was easily seen in the back of the room. She lectured, but moved away from the podium when she referred to the global maps that lined the walls. She engaged students by asking questions and doing demonstrations using simple materials such as a box and notepad. At the end of the class she gave a quiz in which she encouraged them to use notes or speak with their neighbors (AstP_D, personal communication, August 26, 2004).

Table 30 summarizes instructional enhancing media, while Table 26 shows information sources used or wished for by AstP_D. For example, she checked journal and reprints/preprints not because she uses them directly to support teaching, rather they are used to inform her on potential or new background material to include in lectures.

Associate Professor E

Intrapersonal and interpersonal knowledge and information are used to support teaching for AP_E. She has an active research agenda and uses her personal experiences to explain concepts and enhance topics. After converting her introductory lectures into power point presentations, AP_E had a colleague, the department chairperson, review the presentation slides and add suggestions. He recognized the need for digital images, and he took images of specimens in the department's collection and made them available to AP_E and others (AP_E, personal communication, September 9, 2004). AP_E is a mentor for another geoscience faculty member who taught a large enrollment introductory environmental class in his first semester at the university. To help him, she arranged a speaker from the USGS to talk to his class on earthquake hazards; the guest "he had worked at the Air Force base on Mt. Pinatubo" in 1991 and witnessed the major eruption, and he had been in Nevado del Ruiz and witnessed a "big mud flow where people were buried alive" (AP_E, personal communication, December 3, 2004). In addition, the new faculty member arranged for a live, direct satellite link to Antarctica and a colleague spoke regarding his research and answered questions from students. AP_E said this new faculty she was mentoring received *huge, great reviews* from students (AP_E, personal communication, December 3, 2004).

Table 26

Sources to Enhance Geo 104 “Earth in Action” AstP_D

Sources	Used	Wished For
Maps	X	
Globe	X	
Field-trip Guidebooks		X
Open-file Reports		X
Reference & Textbooks	X	
Journals	(X)	
Reprints/Preprints	(X)	
Brochures	X	
Rock & Mineral Specimens	X	
Fossil Specimens	X	
Power Point Slides	X	
Photo Slides	X	
Photographs	X	
Digital Images	X	X
Aerial Photos	X	
Figures/Animation/Cartoons	X	X
Geophysical Well Logs		X
Seismograms	X	
Seismic Simulation Software	X	

Table 26

Sources to Enhance Geo 104 “Earth in Action” AstP_D

Sources	Used	Wished For
Internet Real-time monitoring	X	
Internet Websites, Libraries	X	
Demonstrations	X	
Hallway Displays	X	
Videos/DVD	X	
Colleagues	X	

AP_E believes in the value of relating personal experiences and showing students what it is like in the field. Field trips are not an option with large class sizes, so she brings geologic phenomena to students via personal slides and slides converted to digital images in power point presentations. AP_E related an example that during a class discussion on being "green" or environmentally conscious she said,

> I show them slides of mines. . . .it's good to open your eyes to see what strip mines look like. I mean it's only because people think they're green, but they can't be green and live in a developed world. (AP_E, personal communication, September 9, 2004)

In addition to slides, she relies on audio-video sources such as one on regional historic earthquakes; real-time data and images from Internet sites such as the USGS; world map on the classroom wall; figures, cartoons, and other images to illustrate points (AP_E, personal communication, September 9, 2004). A demonstration she uses to explain Earth's electromagnetic field involves wrapping copper wire around a bolt and making it magnetic with electric current (AP_E, personal communication, September 9, 2004). During the classroom observation, she took the class to the campus geology museum housed in the same building so they could see for themselves the rocks and minerals she had been discussing in lectures. The visit generated questions and enthusiasm among the students and served as a convenient way to show natural resources within their own state and from distant places they might never be able to see.

Creating new classes is a *big time sink* and converting existing class lectures to power point presentations is an equally big time commitment (AP_E, personal communication, September 9, 2004). Time constraints have kept AP_E from converting over all slides to digital, and she is unhappy that textbook publishers do not provide all figures and illustrations in a digital format for instructors (AP_E, personal communication, September 9, 2004). Thus, she acquires two textbooks, one to use for preparing the course and the other to tear apart and lay flat for scanning and converting to digital (AP_E, personal communication, September 9, 2004). When she has other information needs, AP_E goes online. AP_E does not use publisher's websites or DLESE, however she has found other educational websites with images and text that have been useful. In particular, she initiates email communication with other professors, who are using the same textbook and have placed power point slides online. After receiving his approval, she may borrow power point slides and digital images for her course development (AP_E, personal communication, September 9, 2004).

AP_E "picked a deep not shallow textbook. . . harder than most but up to date;" this book shows "seismic tomography" and actually lets the student "see lithospheric plates going down to the core mantle boundary" (AP_E, personal communication, September 9, 2004). Although she finds "it easiest to go straight through the book," they do not have time to cover all chapters. She said there was a lot of material and it is hard to "know where to call the line'" however, she justified her choice of text by saying, "We're trying to make citizens that know a little bit more about science and that's not going to be just our majors" (AP_E, personal communication, September 9, 2004). Table 30 summarizes instructional enhancing media, while Table 27 shows information sources used or wished for by AP_E.

Table 27

Sources to Enhance Geo 105 "General Geology" AP_E

Sources	Used	Wished For
Maps	X	
Reference & Textbooks	X	
Rock & Mineral Specimens	X	
Fossil Specimens	X	
Power Point Slides	X	
Digital Images	X	
Figures/Animation/Cartoons	X	
Meteorological records	X	
Internet-Real time data/monitoring	X	
Internet Websites	X	
Demonstrations	X	
Museum	X	
Video/DVD	X	
Colleagues	X	

Professor F

Most often, P_F relies on intrapersonal knowledge and personal sources to satisfy information needs. One important information need is in having the time to convert her extensive slide collection into a digital format to display or include in power point lectures (P_F, personal communication, June 18, 2004). Even though textbooks come with print and digital images, she explains geoscience concepts through the slides she has physically photographed from her time in the field and mixes her collection with a few purchased slides (P_F, personal communication, June 18, 2004). Although she noted this is "not exactly hands on activity. . . it does give them visually" a clarification of what she is introducing and she has every type of geologic phenomena illustrated from her many travels (P_F, personal communication, June 18, 2004).

P_F is "unimpressed" with Internet web resources and CDs placed in the back of textbooks. She said website materials are either for too young of an audience or not credible sources; P_F went on to say, there is no value in including the same pictures found in the textbook in a digital format on the CD (P_F, personal communication, June 18, 2004). Even an educational website created from a workshop that she attended on her specialty, structural geology, was "not helpful at all" (P_F, personal communication, June 18, 2004). The purpose of the webpage was to share resources, but in P_F's opinion she described this website as a "waste of time" and this type of website "in its infancy" as far as scientific applications for teaching are considered (P_F, personal communication, June 18, 2004). "I'm not going back for a few more years. . . . I'm going to have to be dragged back there and have someone show me something really useful before I'm convinced" that electronic resource sharing is worthwhile (P_F, personal communication, June 18, 2004).

In spite of not using electronic forms of information and resource sharing, P_F does rely on other interpersonal information and sources. She has learned of classroom demonstrations and teaching techniques in face-to-face situations, from colleagues at her present university as well as at past positions, both as student and faculty (P_F, personal communication, June 18, 2004). She attends teaching workshops and the university has brought in outside geoscience education speakers. Although P_F does not use journals to support teaching, she *absorbs* what she reads and may use this information in the course (P_F, personal communication, June 18, 2004). Occasionally she said, a colleague will pass along a photocopy from the Journal of Geological Education with an activity of interest; however, P_F is not a subscriber or reader of this journal although she said she would consider browsing the journal if it was offered online and "at my finger tips" (P_F, personal communication, June 18, 2004). She reported the university had approved hiring new faculty, specifically in geological education; she felt that this person would serve as a bridge with education, a department resource to connect them to activities and demonstrations for teaching, and serve the geoscience education majors as well as K-12 teachers who need additional training (P_F, personal communication, August 27, 2004).

P_F uses the ELMO projection by writing notes that highlight the lecture or displaying a rock or mineral specimen to the class. She said the text display can be seen in the back of the room better than using chalkboard or white board and samples displayed are easy to see and cannot be easily passed around the room in large classes

(P_F, personal communication, June 18, 2004). On the wall is a "beautiful world map in the classroom with earthquake epicenters and raised relief" that she refers to during lecture; she takes in a raised relief globe as well. P_F practices a classroom activity called think, pair, share, where she gives them an idea or a problem to think about; they talk with neighbor and then discuss as a group (P_F, personal communication, June 18, 2004). In addition, one of her physical demonstrations is the p-wave and s-wave dances that bring students to the front of the room to physically simulate energy waves moving through dense rock. Instructional enhancing media are summarized on Table 30 and information sources unique to P_F in to enhance teaching are shown in Table 28.

Professor G

In contrast with other participants, P_G has taught for forty years at the same university where he completed his masters and doctorate degrees. He relies on intrapersonal knowledge and personal sources. He has an extensive personal library in his home and subscribes to a number of scholarly journals that he makes available to colleagues and students. P_G lectures using power point presentations and has a large collection of digital images (P_G, personal communication, September 7, 2004). Personal slides have been converted, and P_G said he scans interesting scenes from the cover of *Science,* for example, to create digital versions to use in his lectures (P_G, personal communication, September 7, 2004). His digital images are shown with power point presentations and P_G said, it was a natural progression for his lectures to move from transparencies and the overhead projector to power point slides and computer projections (P_G, personal communication, June 23, 2004).

Table 28

Sources to Enhance Geo 106 “Earth in Action” P_F

Sources	Used	Wished For
Maps	X	
Reference & Textbook	X	
Rock & Mineral Specimens	X	
Fossil Specimens	X	
Power Point Slides	X	
Photo Slides	X	
Digital Images	X	X
Figures/Animation/Cartoons	X	
Demonstrations	X	
Hallway Displays	X	
Colleagues	X	

Large class sizes prevent him from bringing in specimens for demonstration, "I don't find it reasonable to bring in fossils [for student viewing] because you know they're [fossils] this big and I've got a huge room" (P_G, personal communication, June 23, 2004). Although there is an ELMO projection in the lecture room, he has chosen not to use it (P_G, personal communication, September 7, 2004). He has no interest in learning the online Blackboard system "because it seems like something else to do to invest my time in for too little return because I'll only be doing this [teaching this course] a couple more times (P_G, personal communication, September 7, 2004).

Overall, P_G seemed perplexed with regard to questions about teaching activities or techniques to illustrate concepts beyond the textbook. He responded, "I lecture. That's all I do" (P_G, personal communication, June 23, 2004). When asked how he portrays geologic time to non geology majors, he responded:

> I don't think anyone understands or can grasp a billion years but we pretend that we can. . . . I don't think I do anything special to convey those ideas. I don't give very much thought to what I do. I just do it. So all these questions catch me by surprise and make me feel guilty like I should have been fretting about this for a long time but I don't. I just go in and do it. (P_G, personal communication, June 23, 2004)

When observing his classroom, the researcher noted that P_G indeed lectured from his power point slides and had a microphone which projected his voice clearly in a room that would have held over one hundred students.

The only information need identified by P_G was that "there is no suitable textbook in this field" (P_G, personal communication, June 23, 2004). He said this was "the big problem with the course" and therefore, he is co-authoring a book patterned after the course (P_G, personal communication, June 23, 2004). For his part, he will need few resources because as he explained, " I'm just writing it. . . . just writing from experience. I just use what I know" (P_G, personal communication, June 23, 2004). He was not anticipating any complicated searches for information because writing will be similar to teaching, "I think I can talk for eighty minutes which our standard class is on any of these topics without going and looking anything up" (P_G, personal communication, June 23, 2004). The only difficulty P_G acknowledged was in the illustrations to be included in the book; the authors will "nominate the figures" and then it will be up to the publisher to draft the images in the same scale (P_G, personal communication, June 23, 2004).

P_G was frustrated with the interview questions in general and neither he nor his students in introductory geoscience courses visited the library. P_G stated that,

> I don't feel like I'm helping very much with this [the researcher's study] because I just don't do the things that you seem to be asking about here in this course. And I don't know of anybody teaching an introductory course who goes to the library to get materials for it. (P_G, personal communication, June 23, 2004)

P_G did review a list of instructional enhancing media and information resources to enhance teaching, which are shown in Tables 30 and 29. For example, he used colleagues show a video his class when he attended professional meeting.

Geoscience participants present subject areas and concepts important for projected outcomes, goals, and expectations in a variety of ways. Participants delivered

Table 29

Sources to Enhance Geo 107 “Prehistoric Life” P_G

Sources	Used	Wished For
Reference & Textbook	X	
Journals	X	
Fossil Specimens	X	
Power Point Slides	X	
Digital Images	X	
Figures/Animation/Cartoons	X	
Demonstrations	X	
Museum	X	
Internet Websites	X	
Videos/DVD	X	
Colleagues	X	

lectures, visual activities, and physical demonstrations dependent upon convenient instructional enhancement media available in classrooms, which ranged from chalkboards and overhead projectors to ELMO and computer projections with Internet capabilities. As expected, participants rely upon intrapersonal knowledge and personal sources. Information needs were satisfied by face-to-face conferences and field trips, as well as electronic source opportunities from geoscience professional societies, and teaching and research centers at universities, which enhanced participants' intrapersonal knowledge and interpersonal information. Personal sources were photographic slide collections, assembled to provide visual images of geoscience concepts and processes, but now in need of conversion to a digital format for inclusion in power point lectures. For others, personal sources were virtual simulation software or real-time data requiring computers for interaction and display. Physical demonstrations of geoscience concepts and processes often involved student participation such as the p-wave dance or the plastic bottle with rock and water observed during lecture. Some demonstrations and activities went beyond the participant's immediate sources to include electronic interpersonal relations such as the direct satellite link to a colleague on a distant continent who interacted with a class in the mid-western United States.

Table 30 summarizes the instructional media, while Table 31 summarizes sources relied upon to enhance teaching for participants. Information needs meant participants depended upon face-to-face interpersonal relations, sharing lecture notes and images with colleagues or asking them to deliver lecture, test, or video to their class while away at a conference. Others used electronic interpersonal relations to enhance course development and instruction, sharing lecture notes and images with other

Table 30

Summary of Instructional Enhancing Media

Media	GTA_A	L_B	AstP_C	AstP_D	AP_E	P_F	P_G
Overhead Projector	X	X					
ELMO Projector				X		X	
Classroom Computer			X	X	X	X	X
Power Point Software			X	X	X	X	X
Clicker device						X	
Blackboard/WebCT		X	X		X		
Online Course Webpage				X			
TV Broadcast		X					

Table 31

Summary of Sources Used to Enhance Teaching

Sources	GTA_A	L_B	AstP_C	AstP_D	AP_E	P_F	P_G
Maps	X	X	X	X	X	X	
Globe	X	X	X	X			
Field-trip Guidebooks	X						
Reference & Textbooks	X	X	X	X	X	X	X
Journals				X	X	X	X
Reprints/Preprints		X		X			
Brochures				X			
Rock & Mineral Specimens	X	X		X	X	X	
Fossil Specimens	X	X		X	X	X	X
Transparencies	X	X					
Power Point Slides			X	X	X	X	X
Photo Slides			X	X		X	
Photographs	X	X		X			
Digital Images			X	X	X	X	X
Aerial Photographs		X		X			
Figures/Animation/Cartoons	X	X	X	X	X	X	X
Seismogram/Software				X			
Meteorological records/data			X		X		
Internet Data/Monitoring			X	X	X		

Table 31

Summary of Sources Used to Enhance Teaching

Sources	GTA_A	L_B	AstP_C	AstP_D	AP_E	P_F	P_G
Internet Websites/Libraries	X	X	X	X	X	X	X
Demonstrations	X	X	X	X	X	X	
Hallway Displays	X			X		X	
Museums			X		X		X
Video/DVD/TV Broadcast	X	X	X		X		X
Colleagues	X	X	X	X	X	X	X

educators at distant universities through website postings or incorporating the *clicker* devices to engage students in the lecture offered by vendors and publishers to accompany a textbook. Although everyone mentioned using books to support teaching, most were referring to the chosen course textbook, while some were referring to other textbooks, usually acquired as examination copies from publishers, from which they gained ideas for lecture activities or scanned pictures and figures for projected presentation. All participants used visual props in the form of figures, animations, cartoons, and images in print, slide, or digital formats. Participants used Internet websites in a variety of ways, such as in the classroom displaying real-time data involving volcanoes, earthquakes, and weather-related records, or outside of the classroom as a reference to point to people or information sources.

Thus, in focusing on traditional and innovative teaching techniques, information needs were recognized while formulating plans for lecture, activity, and demonstration. Participants explained their course and instructional schemes consistent with their convenient and available intrapersonal and interpersonal knowledge and information to support teaching. Information needs were satisfied with informal and formal published and unpublished sources of information and data. Although resources were recorded with information needs, the strategies employed by participants follow. Geoscience participants use a variety of means of looking for and gathering sources to support teaching and in addition to techniques, participants' preferences and concerns are described from their point of view.

Information Behavior

Looking for information includes a conscious effort in response to a need, as well as unintentional encounters with sources, and these two means taken together are referred to as information behavior, which may be purposive or passive (Case, 2002, p. 5). For participants, information behavior means looking for sources or serendipitous information to fulfill course and teaching goals and information needs. Participants rely on informal means or intrapersonal information based on their educational and work training, as well as interpersonal connections and exchanges. Beyond this, course and teaching needs are met through formal information sources, commonly reference or textbooks from commercial publishers and for some, accompanying online electronic support. Books have copyright dates and an International Standard Book Number (ISBN); this creates unique identification that allows the work to be placed and found in information systems and databases with potential for universal access. Online electronic sources have a Uniform Resource Locator (URL) for identification that allows various Internet search engines to locate and create links for potential access. Often sources are located through secondary indexing and abstracting database services offered through libraries or directly online, such as GeoRef for geoscience print literature or Google for websites. GeoRef is an expensive subscription for academic libraries and not available everywhere; Google is one of many free ways to search online provided there is access to the Internet.

Results from this study show geoscience participants create and need personal lecture notes, image collections, and activity and demonstration ideas. They organize course materials in a variety of ways, from hand written notes to online course webpages. Lectures are given in a variety of ways, from transparencies on overhead projectors to power point presentations on computer projectors. The course textbook is reported as supplemental reading to lectures, which are complete with illustrations, activities, and demonstrations. Some of the sources participants found useful were field-trip guidebooks, museum collections, maps, natural resource specimens, and print, slide, or digital photographic images. These sources may not be classified and cataloged in a standard uniform manner in a service such as GeoRef. This makes awareness, access, and acquisition problematic for both librarian and participant, and indeed, data shows the participant's academic library and librarian played a minor to no role in course development and instruction for these geoscience participants in support of their teaching. Additionally, participants made it clear to the researcher they neither encouraged nor discouraged students to use the academic library or librarian when given geoscience media assignments. Participants' accounts of their search for formal and informal information sources used to support teaching follow. Specifically, this researcher asked participants to address their use or non use of academic library and librarian liaisons as strategies for obtaining answers and materials in unfamiliar areas.

Geoscience Participants' Strategies for Obtaining Information

No participants at the time of this study were creating the introductory geoscience course for the first time. Although these participants were satisfied with their courses, each one expressed interest in continually enhancing courses by increasing their intrapersonal and interpersonal knowledge and information sources through educational experiences, active research agendas, and participation in professional organizations. For example, during data collection for this research, P_F participated in a two-week summer workshop on teaching in her field of study, while L_B spent a month teaching geoscience in China and GTA_A took a field methods course in Hawaii. Prior to one August interview, this researcher accompanied AstP_C and others, including media reporters, students, and colleagues, to view his research site and hear explanations of the instrumentation and purpose of the project. P_G and AP_E are editors of well-known and respected geoscience formal literature, including a multivolume treatise and a scholarly journal. Several participants had created or edited field-trip guidebooks and currently, P_G is writing the introductory course textbook for commercial publication.

When participants wanted information, they often used the Internet to provide awareness and access to formal published or unpublished sources through geoscience professional organizations or as a path to people. One instance was related by AP_E, who spent 2004 summer months in a sparsely populated area of northern California, USA, doing the field work for her research. Available accommodations were at a campground that had wireless Internet access and she took advantage of this by revising a manuscript, on a topic she would likely use as an example in her teaching on regional earthquakes and geologic structures. AP_E explained that the reviewer urged her to include information from an article in a journal she was unfamiliar with. She had added *Blocks of Docs* to her yearly Geological Society of America (GSA) professional society membership that allowed her to access their journal files and to retrieve articles electronically from 1973-2004 with a 48 hour turn around time. Although she did order and receive articles for the manuscript, the journal in question was not among the offerings at GSA. Through a connection though, she found the email address of the author of the article in question and requested the article directly. The author responded by sending the article to her in a portable document format (pdf) attached to his return email. Hence, she was able to address all suggestions needed for revision of the manuscript and send it back electronically for publication during a summer of field work at an isolated site. She noted that many authors are putting their works online or are willing to send them personally in pdf. Often, her strategy is to go straight to the source and "it cuts the library out completely. . . . I mean the idea is that you want to disseminate this information as broadly as possible" (AP_E, personal communication, December 3, 2004).

When asked how she would obtain an answer for a challenging question from a student, GTA_A indicated that first she would search her available textbooks for the answer. If this was unproductive, she would turn to faculty or other graduate students. GTA_A (personal communication, November 8, 2004) said the very last place she would go is the university academic library. "I don't think I've gone to the library to look up stuff for teaching. . . . so far I've only been teaching really basic information" (GTA_A, personal communication, November 8, 2004). She recounted a search for "coesite-in-diamond geobarometry" in which she had limited success using the academic library; she could not access the *electronic journals* unless she was physically in the academic library and although she became aware of many articles of interest, she was unable to recover them because the library did not have the journal subscriptions. She said "older journal articles can be found at the library" and "the library is conveniently located in the middle of campus" so she stops in to read "news websites mostly and email" (GTA_A, personal communication, November 8, 2004). In addition, she spoke of the newest book she could find in the library on *ball lightning* was from the 1970s, and maps were difficult to check out because they were adding them to the system whenever anyone wanted to check one out, which meant a longer than normal delay (GTA_A, personal communication, August 26, 2004). Thus, GTA_A's strategies for finding course related information is through intrapersonal knowledge and interpersonal connections.

L_B (personal communication, July 13, 2004) enjoys browsing online, books stores, and government surveys for course materials. She obtains information from a state geological survey library located in the city's downtown area, several miles from the university, and wished this library had a cooperative agreement with the academic library for checking out and returning sources. She commented that she rarely uses the academic library because of time constraints and she cannot obtain what she wants; the academic library geoscience journal selections are too specialized for her purposes and her students' purposes, while books are too far out-of-date. Also, she would like to see the library adopt a system of organizing the more recent materials similar to a bookstore with *pods* for each discipline. Thus, L_B strategy for finding course related information in primarily intrapersonal knowledge and personal sources. Her distance teaching mode means limited interpersonal connections; however, she does rely on some colleagues and departmental resources (L_B, personal communication, September 18, 2004).

When AstP_C (personal communication, August 4; September 21; December 3, 2004) depends on the Internet, a privately funded science library, public libraries, research database listings, grant funding organizations, and a post doctorate university research center for information and sources for teaching and research. AstP_C said, when he first visited the academic library his impression was that it contained *dreadfully dated resources* related to his field of interest; and, initially he said he did not go back or recommend the academic library to students. He said he worked with a library liaison to order new books and when asked for information on localing flooding events, they referred him to public libraries. These participants have a unique opportunity in that a privately funded science library is located on campus for their use in addition to the academic facility and therefore, he accesses their resources and said that library was a key reason for his taking the job at the university. AstP_C reported using the main public library as well as a library near his home to check out videos of local interest for his class (e.g., information on flooding of the five major USA rivers that passes through the city). He wished for a cooperative agreement among the public and academic libraries for loaning and returning materials. AstP_C perceives the public library and privately funded library to be more useful to support teaching than the academic library. He said the academic library "only stocks things demanded, which are mostly research requests" not teaching or the instructional materials needed to support information needs of participants (AstP_C, personal communication, September 9, 2004). He did use the academic library though, and the example he gave was to obtain books about a bioscientist, who AstP_C served on a radio talk show panel with; the academic library was able to obtain the author's books through interlibrary loan services (AstP_C, personal communication, December 3, 2004).

In addition to libraries, AstP_C uses the Internet to obtain information and described it as a pointer to find the name of a person or visual images-figures or animations- he can use in class and incorporate into power point slides. He relies on his affiliation with past universities to access resources online and subscribes to *Science*, which provides him access to their journal online and pdf archives, which provide background materials for teaching and researching.

AstP_C calls himself an interdisciplinary scientist and as such he elaborated on the how he obtains information when the topic was unfamiliar to him. He said the answer is simple; he looks for people to work with. He finds a collaborator, colleague or librarian, who is familiar with another discipline's literature, because it would take him too long to get proficient (AstP_C, personal communication, December 3, 2004). He explained that he was comfortable in geography, hydrology, and atmospheric science, but to go beyond and leave these areas he must collaborate with someone with mutual interests that is "you look for people who can add value to what you're doing" (AstP_C, personal communication, December 3, 2004). AstP_C said he would not attend the same conferences of these potential collaborators, rather he would search the Internet and a campus, state, and national research expertise database; he explained, "you add yourself to the database by putting in your specialty and interests." (AstP_C, personal communication, December 3, 2004). In addition he said:

> if I need expertise, you use sources that are familiar to you. So I can call up someone that I'm already working with or have worked with in the past and ask if they can recommend someone to me on this subject. (AstP_C, personal communication, December 3, 2004)

In addition, AstP_C said he meets people through campus committees he serves on. He summed up his position by saying, that as young faculty you base self on your dissertation because that's what you know the best; however, he said, "I've gone away and come back . . . when you go away from what you know you must collaborate" (AstP_C, personal communication, September 21, 2004). Thus, AstP_C's strategies for finding course related information is through intrapersonal knowledge and interpersonal connections.

To inform AstP_D (personal communication, June 18, 2004; August 27, 2004) on information to support teaching, she *googles* and gathers most information online from digital libraries, online journals, educational websites, textbook publisher websites, and real-time data from seismic recording stations. If a question came from a student that she could not readily answer, her procedure would be to go first to her personal books, then online, and finally, to colleagues (AstP_D, personal communication, August 27, 2004). To ensure credibility of online information, she frequented sites she knew to be reliable such as the USGS government sources or journal sites such as *Science* or *Nature* (AstP_D, personal communication, August 27, 2004). She was aware of a library liaison and she would contact this person if she needed to order a book; however, most of her contact with the academic library was through accessing their e-databases. Thus, AstP_D's strategies for finding course related information is primarily through intrapersonal knowledge and online sources.

AP_E (personal communication, September 9; December 3, 2004) obtains information to support teaching in a variety of ways. She searches online through Google for original sources and frequents journals such as *Science* and *Nature* online. She locates other professors' websites and uses their educational materials after emailing for permission. Her reliance on digital sources and communication is demonstrated to students in her introductory course; "I post everything up on WebCT so they can download my lecture, power point presentation, images and word documents" (AP_E, personal communication, September 9, 2004). For her introductory course, AP_E uses real time data and other materials from the Internet, downloaded and displayed or obtained in class through the Internet connection. She explained:

> I supplement textbook images with stories and things from the Internet. . . . I have real time water monitoring . . . we do hydrographs of the local streams and all the floods. Two weeks ago we had six inches of rain and streams went to ten feet above normal discharges. (AP_E, personal communication, September 9, 2004)

She went on to say that this gives the student real experience and they actually *see it*; also, she goes to volcano monitoring stations such as Kilauea in the Hawaiian Islands and downloads images to show in class. AP_E goes to special libraries or field sites for materials as well, in both a physical and digital presence.

For research, AP_E spoke of her field work in Jordon, where she has the time to visit an American Jordian research library and acquire relevant "gray literature sources such as dissertations, theses, and local work" (AP_E, personal communication, December 3, 2004). For teaching, she spoke of directly contacting a state geological survey to obtain materials for inclusion in class and creation of a field trip for another class. To obtain background material for the topic of "carbonate rocks," AP_E obtains first hand information by "leading a field trip to view modern carbonate rocks to be better able to interpret ancient examples" (AP_E, personal communication, December 3, 2004). In addition, she spoke of the value of attending and networking at international and national professional meetings, where information and sources can be easily obtained through meeting people with similar interests and exchanging ideas and professional papers. With regard to her local academic library, she said she had not used the facility in *nine years* and that "our holdings are not that extensive. . . No I don't go [to the academic library], they don't have anything" (AP_E, personal communication, September 9, 2004). However, she did say, "when you look at the use of librarians, at least it's for me, it mostly with the research" not teaching; she might consider having librarians organize articles in a higher level seminar class (AP_E, personal communication, September 9, 2004).

AP_E sends students to the privately funded science library on campus and is pleased for this library's access to the GeoRef database and their acquisition of obscure articles for her (AP_E, personal communication, September 9, 2004). In addition to teaching and research needs, she uses the privately funded library to complete an administrative responsibility; each year to put together the faculty activity report, she accesses Science Citation Index to record information on the number of people who cite her research works (AP_E, personal communication, September 9, 2004). Thus, AP_E's strategies for finding course related information is primarily through intrapersonal knowledge, interpersonal online sources, and specialized science libraries.

To help students and colleagues to locate information, P_F (personal communication, June 18, 2004) created a reading room in the geology department, made up of personal subscriptions, unofficial and separate from the academic library. When the researcher arrived for the first interview, P_F was culling her office collection of journals dating back to 1987 and going "to have a student fill in any gaps in the reading room with [her] journals and throw rest out." She explained, "I'm trying to sort of weed out. . . . the library does not get this journal so I feel obligated to have it" (P_F, personal communication, June 18, 2004). She went on to say:

> the academic library has been trying to cut journals and *Journal of Structural Geology* I think is one of those Elsevier journals that cost the library some $3000 a year or something ridiculous . . . it's so much money for one journal that's sort of specialized . . . there are other journals they can get for $400 a year that may be of more general interest (P_F, personal communication, June 18, 2004)

When the researcher asked if she went to the library, she replied, "For what . . . the library here on campus? No and you know I can't think of what they might have in Earth Science or geology right now that I wouldn't find in these other sources [in her personal collection]" (P_F, personal communication, June 18, 2004). She spoke of face-to-face exchange of information and sources used to support teaching, through colleagues and professional organization workshops. Thus, P_F's strategies for finding course related information is primarily through intrapersonal knowledge and face-to-face interpersonal sources.

When P_G was asked how he obtained information and used the library, he responded, "I don't use the library for example for anything. . . . I use journals that I subscribe to and I use books that I have" (P_G, personal communication, June 23, 2004). With regard to revising lectures, he said,

> I have a lot of preconceived notions some of which are probably not right but they make the point so. . . . I don't set out . . . to revise a lecture. I just start doing it from what I know and when I find I need to go look

> up something about Cambrian explosion. . . mostly the things I look up are things out of a book so I can have pictures to show people. (P_G, personal communication, June 23, 2004)

P_G suggested that he was being *curmudgeonly* but believed his academic library to be:

> all messed up and at some point somebody needs to mess with books. . . . I realize that we're in the middle of a major revolution in information. . . . I'm just delighted that I'm going to be able to miss it, because it looks like a real nightmare. (P_G, personal communication, June 23, 2004)

He went on to reminisce when GSA was "trying to be on the cutting edge and they were all going to microfiche" (P_G, personal communication, June 23, 2004). He said it was difficult to read and the microfiche reader was not portable; he described it as a *complete mess* (P_G, personal communication, June 23, 2004). Although he said emphatically he did not use the academic library for the course in question and that his own library is extensive and current, he later added that he sent people to the library *daily* to get things he did not have (P_G, personal communication, June 23, 2004).

P_G is writing the textbook for the course, based on his extensive intrapersonal knowledge, and he is not anticipating any complicated searches for information. P_G has told his publisher that he would *nominate* illustrations and they should redraft them in a consistent scale. If the need to obtain information, he was confident he could find everything in his library or if need be, he would ask a colleague. If placed into a situation of teaching a course he was unfamiliar with, P_G said he would:

> fall back on my notes and find a good textbook and let it guide me through. . . . I would probably try to extort free books from as many

> publishers as I could and hope I'd have a little lead time to go through them and find one I liked. I would want to know from the department what they expected of that course. . . . We don't do as much of that as we should. (P_G, personal communication, September 7, 2004)

Thus, P_G's strategies for finding course related information is primarily through intrapersonal knowledge and personal sources.

The Role of the Library Liaison

The library liaison is not the first choice as a resource for GTA_A. The library liaison was visible to GTA_A (personal communication, June 18, 2004) as the person who talked about using the GeoRef database service. However, she felt she had mastered that system and would not probably go back to the liaison for help because "he's not a geologist. . . . He may know how to find things in the library but if he doesn't know what I'm talking about . . . then it's not the same language" (GTA_A, personal communication, June 18, 2004).

L_B (personal communication, July 13, 2004) was unaware of any library liaison program at her university, while AstP_D (personal communication, June 18, 2004) was aware of the liaison but believed his role to be one of ordering books. In speaking with P_F of the same liaison AstP_D knew, she agreed that one of his duties was in obtaining new books and journals. However, P_F (personal communication, June 18, 2004), who was also the chairperson for the department, went on to say "he covers many different departments," and had been in contact with her regarding the geoscience specialties of her faculty. She described him as being "ten steps ahead of me, "our guy," and "he's a great guy." Although she does not send students in from her introductory class to the liaison, she does encourage geology majors to speak to him about online database searches (P_F, personal communication, June 18, 2004). She voiced concern about students not using peer-reviewed journals and instead, taking sources off the web or purchasing complete term papers. Although, P_F had a positive opinion of her academic library liaison, it was not clear if she had personal contact beyond discussing her potential information needs of her faculty and students. Also, P_F spoke favorably, at some length, about specific geoscience librarians at universities where she did her undergraduate and graduate work.

AstP_C reported their library had gone through a consolidation, eliminating the liaisons for each department, and creating one liaison for all of science. Although he worked with this person to order books to replace the out-dated collection of sources related to his field, he said the journal process was more complicated and there were no funds for science journals (AstP_C, personal communication, August 4, 2004). AstP_C affirmed that this interview and research study had made him realize he should engage the librarian by taking his syllabi over to see what interactive videos or other sources they may have to support teaching (AstP_C, personal communication, December 3, 2004). He viewed himself as a consumer of products and services at the library and said, "we tend to look at the library as a place to go to, not as a place that comes to you" but now sees himself as the one who needs to initiate contact (AstP_C, personal communication, August 4, 2004).

AP_E (personal communication, September 9, 2004) does not know the liaison and reported that she is not organized enough to tell someone else what she wants; she believed it would take longer to explain than to just do it herself. When the subject was first broached, AP_E thought this researcher was talking metaphorically and meant DLESE or GeoRef. Although she was unaware librarians at her current university, she spoke fondly of the head librarian at the university where she did her graduate work. AP_E said the woman not only remembered her, but was likely responsible for getting her on as editor of a major geology journal.

P_G spoke of a geoscience department faculty representative to the library, but he was unaware of a specific person serving as liaison from the library. He was not interested in having contact with any library representative because "the only time I hear from that person is when the library says here's a list of journals, cut 10%; and they did" (P_G, personal communication, June 23, 2004). P_G (personal communication, June 23, 2004) had taught for 40 years and had created an ideal information exchange system for him and others:

> I know most people subscribe to a fair number of journals and we trade them back and forth too. It's just more convenient. You may have noticed that stack of journals out there [in an outer waiting room of his office]. Those are the ones that I subscribe to and I send out an email every time a new journal comes in and I'm through with them and people come and read them. I want to have those journals in my own library. I think it's essential to subscribe to a number of journals.

He explained the journals were used to copy illustrations for the Treatise he edited as well. P_G relied on his personal library and expected other colleagues did likewise (person communication, June 23, 2004).

Summary

This chapter presented data gathered from the interviews, document reviews, and classroom observations. These results will be analyzed in the next and concluding chapter. The final chapter will include a discussion of the research questions and the implications of this study as it relates to the field of library and information management.

CHAPTER 6

DISCUSSION

The purpose of this study was to investigate the information needs and behaviors of geoscience educators and specifically, as expressed in classroom teaching. Constructivism and sense-making were the theoretical and methodological frameworks used to understand and view the way participants develop and convey course content and instruction through introductory geoscience curriculum. The research questions that guided this study were formulated to determine information preferences and concerns associated with teaching from a purposive sample of geoscience participants. In addition, questions targeted the nature of geoscience information that participants considered vital to present and the information sources that they found useful. However, the underlying questions were about the place of the library and librarian in the sense-making, constructivist approach to geoscience educators and about the resource formats and instructional delivery styles that are made explicit in the sense-making, constructivist approach of geoscience educators.

In this study, participants discussed where they gathered resources for teaching and their involvement, or lack of, with their academic library and librarians in order to fulfill their course goals. The aim of the research was to facilitate a description of the information needs and behaviors of participants to enhance teaching, which would complement literature on geoscientists' information behaviors in support of research.

This was a grounded theory study, and as such, no a priori model was tested. Rather, the purpose of the research was to look for a model that would emerge, grounded in information gathered from participants (Glaser & Strauss, 1967; Strauss &

Corbin, 1998). Although no a priori model was tested, various models of information needs and behaviors posited by Dervin (1992), Foster (2004), Kuhlthau (1993), Leckie et al. (1996), Wilson (1981), and Wilson and Walsh (1996) were reviewed. Finally, the analysis and understanding of the results of the study follow with discussion, conclusions and implications.

The Information World of Geoscience Participants

By focusing attention directly on the viewpoints of the geoscience participants, in the context of a university work environment, a simple model emerged and is presented in Figure 10. This model depicts the participant's information world by showing patterns for information outcomes, needs, and behaviors with specific course development approaches of goals, subjects, and sources. Results are depicted as two multidirectional triads of events and approaches with accompanying actions, which are within the greater context of teaching at a university. Core events involved in satisfying information needs are shown in upper case lettering. Core approaches involved in developing a course are shown in a mix of upper and lower case lettering. Accompanying actions encircle the participant and are in all lower case lettering.

Core events define specific sense-making and core approaches define specific course developing activities for participants' to complete their teaching task of course development and instruction. Each of these six components of the participants' information world are described using an action term. Actions accompany overall procedural steps for satisfying information needs for teaching. Course information outcomes are met by (a) thinking about goals, (b) focusing on needs, (c) selecting

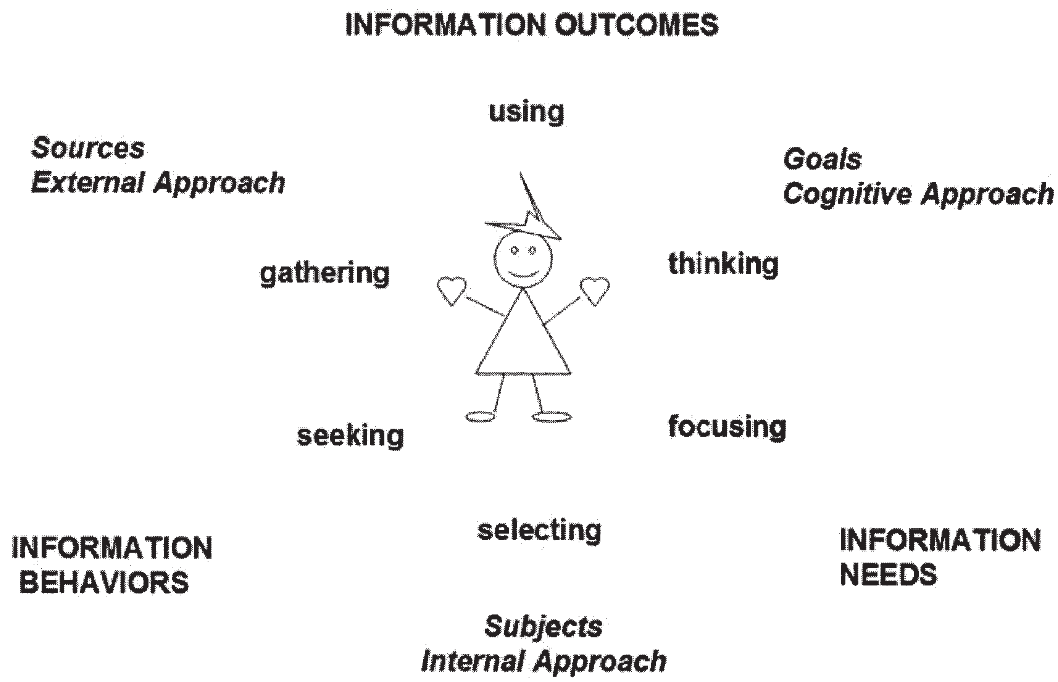

Figure 10. Information World of Geoscience Educator Participants.

subjects, (d) seeking information, (e) gathering sources, and (f) using information. Participants applied a cognitive approach when defining goals, expectations, and outcomes for course and instruction. They relied on intrapersonal knowledge, an internal approach, to identify subject areas, concepts and processes. The participants searched beyond personal sources, an external approach, to gather information for lecture, activity, and demonstration.

Specifically, the pattern that emerged began with participants initiating or inheriting curriculum development and applying their expertise and experience to project outcomes for introductory geoscience courses. Developing the particular introductory course involved thinking through personal course and teaching goals and expectations. Once established, these goals and expectations led to focusing on the information needs to accomplish objectives. A course outline emerged by selecting broad subject areas, concepts, and processes considered vital to present for a comprehensive introduction to the particular geoscience focus. Information behaviors followed as participants were actively and passively seeking sources and instructional techniques to use for lectures, activities, and demonstrations. After exhausting personal and departmental sources, participants were actively gathering information sources external to immediate colleagues, department sources, and self that would be consistent with available instructional enhancing media and appropriate for classroom or distance learning modes.

Internal and external contextual factors that interacted with events, approaches, and actions were identified and shown in Figure 11. External factors were evident in

INTERNAL-PARTICIPANT

Subject area training　　Work experience

Career stage　　Source convenience

Time constraints　　Intepersonal networks

EXTERNAL-UNIVERSITY	GOALS	EXTERNAL-STUDENT
	$\updownarrow$	
Research expectations	SUBJECT AREAS	Weak background
Service expectations	$\updownarrow$	Negative attitude
Funding constraints	RESOURCES	Low attendance
Department resources		Fear of science

Academic library limitations　　Religious preoccupation

Student credit hour production-Recruiting majors

Figure 11. Contextual Factors Affecting Participants' Course Development.

participants' concerns with course or teaching goals and expectations, while internal factors were evident in priorities and preferences involving subject area and source choices. Internal factors were related to participants' backgrounds and were most evident in association with identifying information needs and selecting subject areas. Some external factors, not directly under participants' control, were related to university policy and expectations. These factors were most apparent when participants discussed their external approach or gathering sources external to department resources and self. Other external factors include students and these were most evident in the projected outcomes and planning the overall curriculum and specific course design. These factors primarily affected the cognitve approach to course development including course goals and expectations for content and instructional delivery. Each step in course development as described by participants is discussed in order to shed light on the model of participants' information world as it relates to their teaching role.

Projected Course and Information Outcomes

The participants in this study explained that projected course outcomes were three-fold: (a) introducing the nature of the course subject area, (b) attracting new majors, and (c) generating student credit hours. The course outcome for participants was to present enough information for a broad introduction to that aspect of the geosciences represented by their courses. For example, the participant teaching "Prehistoric Life" defined his course outcome as providing information on prehistoric life from a geoscience perspective. The second course outcome, attracting new majors, was evident when all participants expressed interest in this outcome. For instance, one participant said she wanted to *hook* students on geoscience. The last course outcome, generating student credit hours, was identified by a participant when he suggested that student credit hour production was a preoccupation among administrators. This participant's introductory course had a geoscience course number, yet was offered as a biology distribution requirement. While most participants noted the majority of students in their classes were there to satisfy general education requirements, one course was designed as a prerequisite for geology, geography, or environmental studies majors. Thus, the projected course outcome reported by participants was to attract a few new majors, while generating student credit hours introducing aspects of geosciences and geoscientists to science and non-science majors.

Although one chairperson explained that most of her faculty do not like to teach introductory courses, all of the research participants appeared to enjoy teaching their introductory courses. However, many expressed concerns with class size. One participant suggested that large class sizes were detrimental to student and faculty. Although projected information outcomes remained the same for chairpersons regardless of class size, participants spoke of adjusting their personal course and teaching goals and expectations with larger enrollment classes, with fewer assignments and exclusion of off-campus field trips, along with participants creating ways to improve attendance.

Course and Teaching Goals, Expectations, and Outcomes

Participants' syllabi were course outlines that included information topics and activities for the semester. This document commonly described the purpose of the course and the participants' expectations and projected outcomes. A teaching goal that was commonly shared by most of the participants was to create student excitement for the geosciences and provide an understanding of the geoscientists' work. These participants sought to accomplish this by making the course interesting and realistic through special speakers and geoscience application. For example, a direct satellite link to a researcher on another contintent who provided a lecture and answered questions on his work with issues in the geosciences. Participants included a report of their research, course, or work experiences in their lectures as a way to show the practical applications of course concepts. In one case, a participant with a seismology background created an assignment using earthquake simulation software in which the student assumed the role of a geoscientist who determined the geographic origin of the simulated quake.

Participants noted that a low number of science majors and a high number of non-science majors were enrolled in their introductory courses. Participants suggested that because the majority of students taking these courses were only there to fulfill a graduation requirement, expectations were adjusted accordingly. According to several participants, they wanted to avoid "information overload." Participants agreed that when students are given too much information, they would be more likely to "walk away from" or "drop the class." In addition, some participants referred to the students' lack of a science background, their poor attitude, and their low attendance as a source of concern and frustration in course design and expectations. One participant explained that she had to *reteach* the periodic table, which was a classification tool of chemical elements that she assumed all students had exposure to in high school. Another participant remarked on the high number of nontraditional students in her class; she believed that these students had an even greater fear of science than younger students coming into college directly from high schools. One participant noted that her students could not learn if they were not in class; another participant affirmed this in thaat even though she posted her power point lecture slides online, she reported that there was a correlation between low attendance and poor performance on course assesment assignments. Most participants used the unannounced quiz or brief activity given and collected in class to act as a means for encouraging student attendance.

Several participants projected course learning outcomes beyond memorizing facts. For instance, one participant wanted students to gain a practical vocabulary and sufficient understanding of concepts so that "when they read about their city's landfill being full or ground water contamination or the aquifer running dry, they know what that means."

Although participants expected that students could gain understanding and make real-life connections when presented with geoscience content and thinking, several participants noted that students' preoccupation with religion was a barrier to learning. Specifically, participants were concerned when students projected their religious beliefs and opinions during class meeting times, and this content and thinking was contrary to the premises upon which geosciences and other sciences rely. One participant pointed out that she would not discuss creationism or intelligent design in class again, while another participant explained that she routinely asked students to bracket religious opinions and set aside proselytizing for the duration of the course. While participants speculated these students were in the minority, they consistently disrupted classroom lectures and hampered teaching and learning.

In response to contextual factors, the participants reported that they avoided lengthy assignments or student presentations, which were routinely required in classes with smaller enrollment, and they developed other ways to engage students in learning. For example, the participants moved around in the classroom instead of lectured behind a podium and involved students in classroom demonstrations about topics. In addition, they asked students to focus on geoscience-related current events in order to create a greater awareness of the importance of geoscience in students' lives. While other assignments enhanced course goals and outcomes, participants believed that lectures, activities, and demonstrations conducted in class promoted sense-making best through geoscience applications and illustrations.

Participants' discussions of their class activities made explicit the information needs and subject areas that were pertinent to them. Recognizing information needs to meet course and instructional goals seemed to be somewhat simultaneous with identifying subject areas vital to present the nature of the geosciences.

Information Needs of Geoscience Participants

As might be expected, what emerged from the data were that information needs were less a gap in an participant's understanding and knowledge of content, and more of a gap in determining effective sources and presentation media needed for teaching. Therefore, information needs to enhance teaching were related to developing lectures, activities, and demonstrations, as well as to presenting the course through instruction and enhancing media. Participants related the information sources they utilized and wished for, as well as the instructional enhancing media available and desired.

Athough information needs varied with the narrow or broad focus of the introductory courses, data showed both commonalities and differences. Additionally, information needs were not as apparent to participants because no one was creating a course for the first time.

An obvious information need is in locating an effective course textbook to bolster what the participant believed to be vital to present. Participants used customized and commercial sources and one participant was in the process of writing a textbook for his course. Some participants mentioned the use of other text and reference books for additional illustrations and demonstration ideas. Another information need was related to effective visual media and participants wanted more sources for illustrating concepts. All participants showed either photographic prints and slides or digital images and power point slides depending on available equipment. Every participant used figures, animations, and cartoons for instruction. All participants reported using demonstrations, with the exception of the participant who had the longest teaching career. This same participant was the only one who did not use maps to enhance teaching. He explained that he did not know of any other instructor who used maps for introductory classes.

Nearly all participants showed actual rock, mineral, and fossil specimens in class; one participant who taught the laboratory course spoke of the need for new, larger specimens. All participants referred or took their class to the campus geoscience museum or hallway displays with the exception of one participant who was at a university where neither resource was available. A few participants made use of seismic recordings, meteorological records, and brochures, while one participant wished for additional sources such as field-trip guidebooks, government open-file reports, and geophysical well log data. While some participants checked off that journals and reprints or preprints were used to enhance teaching, they qualified this by saying sources were read to keep current in their fields and not specifically to create lectures.

All participants relied on colleagues as sources for either exchanging lecture materials or taking their class over when they were gone from campus. One participant thought she would benefit by additional contact with colleagues; her course met on nontraditional days and her interaction with faculty was limited. Most participants reported that they obtained needed information from Internet websites, while one participant explained that she used the Internet to look, specifically, for geoscience focused digital libraries and to access the academic library's e-database services.

Information needs directly related to presenting lectures and demonstrations varied with the type and circumstance of class. Most participants showed video clips or videos in class to illustrate concepts and to supplement or to substitute for their lectures. Although one participant met his class twice a week from 5 p.m. until 7 p.m., most participants met their classes one to two times a week for one and a half or two hour time blocks, between the hours of 8:00 a.m. and 4:00 p.m. However, one participant taught a course that combined Saturday campus meetings and distance learning. In this course, students were required to watch some 26 hours of videos and TV broadcasts from the campus station. The participant expressed a desire for increased awareness of and access to additional audio-visual geoscience sources with a balanced but interdisciplinary focus that was age appropriate, up-to-date, and complementary to a textbook.

Information needs directly related to presenting lectures and demonstrations were sometimes constrained by a lack of time or funding. For instance, if participants had the time and instruction or funding necessary, then they would convert their extensive photographic slide collections into digital images to better convey information in lectures through power point presentations. Additionally, university funding determined the available instructional enhancing media in classrooms, which controlled to some extent whether or not information needs were satisfied. For example, participants who taught in a room equipped with only a chalkboard and overhead projector, utilized chalk drawings and transparencies; participants who taught in a room equipped with a computer projection system with power point software and Internet capabilities, utilized power point slides and digital images as well as real-time data and information sources, such as earthquake monitoring or meteorological records. The two participants in the sparsely equipped rooms wished for computer and power point capabilities, which they believed would aid in more effective delivery of lectures, activities, and demonstrations.

Information needs related to presenting course material were satisfied electronically as well. One participant adopted *e-instruction* during the semester of the researcher's observation. In e-instruction, students were required to purchase a textbook and an electronic device or clicker that displayed and recorded their answers to questions shown on a screen during class time. The participant used this method in order to better engage students in large enrollment classes. Whether her information needs were satisfied using this method was yet to be decided. In addition, some participants utilized online enhancement systems to engage students outside of class time. While only one participant had an online course webpage, several participants posted power point lecture slides, announcements, and activities via a password protected version of an online course webpage. However, one university was in the process of changing systems, from *WebCT* to *Blackboard*, and participants needed training and information on how to utilize the replacement system.

As participants discussed their course and teaching goals, they recognized information needs. Somewhat simultaneously, they were able to identify the subject areas that were vital to presenting the nature of the geosciences specific to their focus.

Subject Areas, Concepts, and Processes Covered in Introductory Geoscience Courses

Syllabi were among the course documents examined. These course outlines listed the subject areas to be covered on specific dates during the semester. The participants elaborated on concepts and processes within these subject areas during the interview process. After concepts and processes were identified, the researcher coded these topics within the 94 categories believed to be fields of teaching and research under the umbrella of geoscience as listed in the AGI Geoscience Directory. See Appendix A for the complete list of all possible specialty areas. These categories are grouped within 10 broad subdisciplines, and an eleventh, *other* geoscience subdiscipline category. In addition to the other geoscience subdiscipline category, one *other discipline* category was added.

What emerged from the data was that while most subject areas mentioned by participants in this research were within the eleven broad geoscience subdisciplines, every participant reported covering subject areas or concepts outside the geosciences. Among the eight courses examined, a conservative reporting of other disciplines covered in introductory geoscience courses included anthropology, archaeology, biology, business, environmental studies, chemistry, economics, physics, and political science. Although biology, chemistry, and physics were mentioned most often, data clearly demonstrates the nature of the geosciences includes interdisciplinary scholarship, which every participant noted. Introductory courses with a narrow focus covered the fewest categories and were likely to be taught by a specialist in the area. For example, the "Prehistoric Life" course was taught by a paleontologist and included subjects from geology, paleontology, and biology, as well as one topic in the subdiscipline of geochemistry, geochronology or geologic time. Introductory courses with a broad focus covered a greater variety of categories. The course titles, "Understanding Earth" course incorporated subjects within every subdiscipline of geoscience and several disciplines beyond the geosciences; this course was taught by a participant who described himself as an interdisciplinary scientist. Regardless of participants' research and teaching specialties, every participant included subjects within the geoscience subdivision of geology. One subject area covered by all participants was the theory of plate tectonics, a unifying theory for geology. Hydrology was another commonly used subdiscipline, with surface and ground water and accompanying processes as popular topics covered by nearly all participants. Thus, as participants presented topics and concepts they incorporated in the course, they spoke of the variety of personal and external sources they sought and used to illustrate these subject areas.

Geoscience Participants' Information Behaviors

After identifying information needs and subject areas, participants turned their attention to seeking information sources. Participants emphasized a range of subject areas and satisfied accompanying information needs initially by seeking personal or departmental sources. At one end, the forty year teaching veteran had an extensive personal library and did not seek information externally for his courses. He indicated his greatest information need was for a suitable textbook that was comprehensive of vital subject areas and it did not exist. Thus, he was in the process of writing the course textbook for a commercial publisher. This professor was writing the book from a combination of his lifetime researching and teaching experiences, and he said he might use a reference beyond his personal knowledge if he needed specific information such as the date of birth or death of a historic geoscientist.

At the other end, for the participants newest to teaching, covering vital subject areas and satisfying accompanying information needs and behaviors were more noticeable because personal sources and research experiences were sparse. These participants relied more on colleagues, departmental sources, the Internet, and libraries. However, participants made it clear that they did not frequent their academic libraries and librarians for information to support teaching their introductory courses.

The participant with the least teaching and researching experience said that making several visits to her academic library, she has concluded that it would be *the last place* she would go for information sources related to geosciences. Likewise, other participants at other schools reported visiting their academic libraries, but had little success in finding sources to support teaching. One participant speculated that the academic library is stocked on demand and that the library's mission may be focused on individuals' research needs. Participants suggested that academic libraries lacked the types of geoscience sources needed for teaching because sources in their academic libraries were too specialized, techical, or outdated for introductory level courses. This participant said that when he inquired about video and image sources on a topic of local and regional significant, he was referred to the public library. Other participants spoke of using public libraries and various state or federal geological survey libraries to seek information for teaching.

Seeking information to fulfill course and teaching goals, involved informal and formal sources and both active and passive gathering of information teaching techniques. As a participant noted, an active effort was a search for known information which, for example, could be found in a field-trip guidebook of a certain region acquired through direct access to the state geological survey via her email request. Another participant said his former university association and NASA grant provided him access to data and colleagues, while his participation in professional organizations was useful as well. When one participant was seeking information from a journal article she could not obtain, she went online to locate the author's email address and made her request directly to the author. The request was acknowledged and she received a copy of the article from the author, electronically via pdf. She added that although this bypassed the library, the important point for geoscientists was to disseminate information as widely as possible.

Passive efforts of information seeking were less purposive information behaviors and more serendipitous. This was the case with many participants who have their courses developed and were mostly interested in updating. Participants related their most successful passive efforts were from attending conferences or workshops, browsing bookstores or journals, and encountering colleagues or professionals in a face-to-face or digital situation. For example, one participant told of meeting a colleague in the hallway who passed along a geoscience activity idea. Another participant reported she placed a search term, such as a notable geoscientist's name or textbook title, into the online Google search engine "just see where it would take me." One participant reported when he wanted to explore for information on an interdisciplinary topic, he looked to colleagues who would collaborate; such as colleagues he served with on university committees or researchers he identified while browsing databases of research specialty listings. Participants reported that they did not use academic librarians as intermediaries in information seeking. One participant explained that she was not organized enough to relay her needs to a librarian and as several participants suggested that their academic librarians were not geoscientists and did not "speak the language."

Thus, while convenient interpersonal information and resource exchange occurred for all participants between department colleagues, seeking information and sources within a disciplinary field other than geoscience or exploring topics in an interdisciplinary field of study involved active and passive serendipitous electronic communication or face-to-face situations as well. For example, one participant encountered useful information for teaching, related to geoarcheaology, by attending a presentation at a geology conference in Italy; after the formal presentation, the participant talked with the speaker who suggested names of other geoscientists with like interests; the presenter later sent the participant several useful articles. These articles were in literature sources the participant was unaware of and formats librarians label gray literature, making access and acquisition unlikely under any other circumstance.

Although all participants in this study utilized online resources or communication, the two full professors referred more often to print sources and face-to-face encounters. One of the full professors helped to create her department's reading room with personal journals and was active in campus peer-review teaching programs and teaching workshops. She did not believe the geoscience related teaching activities she had visited online had merit, and she did not encourage students to use information from the Internet for completing assignments. The other full professor had created his own reading room for his students and colleagues to access. He repeatedly mentioned the value and convenience of his extensive library of books, journals, and images in finding information, as well as a university research collection, which consisted of fossil specimens. He gave brief assignments that involved accessing the Internet for information, in part because he was concerned about sending large enrollment classes to the library to examine a print source. He said the resource would probably be destroyed after one semester.

While intrapersonal knowledge and personal information sources were related to participants' educational and work training experiences, all participants, regardless of career stage, had a network of people and resources for obtaining information. The full professors mentioned face-to-face encounters as being most helpful while in constrast, other participants of lesser rank tended to interact electronically with people both known and unknown to them. For example, one participant searched online for the name of the textbook, which resulted in other educators' course websites; she then requested permission to use images from the website via email. Thus, in addition to intrapersonal knowledge and personal sources, participants' information-seeking behaviors went beyond personal or departmental connections and external sources were gathered both physically and electronically.

Sources and Resource Formats

Information gathering behaviors for participants varied to produce desired results. Participants sought and gathered information from: (a) formal and informal sources, (b) internal and external facilities, and (c) physical and electronic formats. In addition to literature sources, information was gathered through first-hand observations and experiences. As might be expected, one obvious formal source for information was the textbook. Although participants reported using course textbooks, they reported that this book was supplemental to their course instruction. These participants did not *teach* from the book and as one pointed out, educators (a) develop ideas about the course, (b) hunt for a textbook that is close to those ideas, (c) use personal experiences to talk about course topics, and (d) assume the textbook will bolster their lectures and illustrations. This participant believed every course was customized and for instance, he did not believe any faculty ever used study questions at the end of chapters in textbooks.

Another participant said she would not use the figures provided by the textbook publishing vendor because they were redundant and students could view those in their textbook. Participants showed their photographic slides or digital images of their experiences to their students as they discussed their first-hand knowledge in a manner similar to Force's (2000) *being there, storytelling*, and *living together* that he observed of geoscientists in the field to enhance sense-making of the particular situation.

When participants were interested in gathering additional information for demonstrations, activities, and illustrations to explain subject areas, concepts, and processes, they often went *into the field*, physically or electronically, to support this aspect of teaching. For example, before the interview, one participant invited this researcher into the field to explain his current project, which was of local and regional significance and of interest to his students. Another participant said her introductory students were most interested in hearing their instructor explain her local and regional research. Another participant teaching the laboratory course took her students into the field on three separate occasions to use the knowledge they had gained in the classroom by seeing examples firsthand. Other participants mentioned field excursions as the best way to show students what they meant; however, participants were unhappy with large class sizes which prohibited the actual off-campus experiences.

Where instructional enhancing media was available, participants took their students into the field electronically through real-time data and meteorological records, volcano and earthquake monitoring sites, or a direct satellite feed to Antarctica for hearing and viewing scientific research. Where museums or hallway displays were available, participants took their students to these exhibits. In addition, participants brought rock, mineral, and fossil specimens to class and passed them around or displayed them on the ELMO projection device. The participant who took part in a summer field methods course in the Hawaiian Islands, brought maps, photographs, and specimens she collected to her class to supplement her stories for the lecture regarding igneous rock and volcanoes. Through this manner of teaching, participants illustrated research methodologies as well as geoscience content by gathering sources or taking students to the information directly.

Participants used their intrapersonal knowledge and interpersonal connections to create lectures in a classroom with real-time experiences by inviting guest speakers physically and electronically if the appropriate instruction enhancing media was available. Participants illustrated concepts within subject areas both visually and physically and they suggested these visual aids were essential created to aid in student sense-making. Personal visual media collections and commercial figures, animations and cartoons were gathered to enhance demonstrations, activities, and assignments. For these participants, sources used and wished for to enhance teaching included regional field-trip guidebooks, maps, physical specimens, images, or meteorological data and few participants reported finding these resource types and formats in their academic libraries. One participant specifically referred to the resources she sought and gathered as gray literature and noted the problematic awareness, assess, and acquisition. To gather material she frequented special library facilities such as a science specialty research library and government survey facility, both physically and electronically. Other sources and information were gathered from special focused digital libraries and authors or participants external to the participant's university. Some participants mentioned obtaining information from professional organizations (e.g., GSA Blocks of Docs). Participants gathered resources from public libraries, textbook publishers, and resource supplying vendors.

Many participants spoke with a sense of nostalgia when discussing their experiences at libraries specific to the geosciences, which included their degree granting university libraries and for one participant, a USGS library related to a sabbatical leave from the university. While convenient sources and tools are obtained from personal or departmental collections, other resources involved considerable effort and networking. In listening to the various means for gathering information and resources for teaching, the researcher concluded that in the absence of useful source materials in the academic library, the participants had devised a kind of *invisible* physical and electronic education network similar to Price's (1961) *invisible college* concept for scientific research communication where findings were communicated directly without waiting for formal publication channels.

How the Data Answered the Research Questions

This study investigated the nature of subject areas and the variety of resource types and formats used by a purposive sample of geoscience educators that enabled them to fulfill their teaching role. Research questions guided the participants to discuss their preferences and concerns in course development and instructional planning. The role of information in introductory geoscience course development and instruction emerged and is discussed in relation to each research question.

Research Question One: Academic Subject Areas Covered in Introductory Geoscience Courses

Subject areas were found in each of the eleven broad subdivisions and 94 teaching specialty areas of the geosciences as listed by AGI, as well as additional disciplines considered outside the geosciences. See Table 32 for a summary.

Every participant reported using subjects within geology, geochemistry, and disciplines outside the geosciences. A subject area that the participants reported using in seven out of the eight courses examined was hydrology. Six participants reported using subjects from economic geology, engineering geology, and oceanography. The participants reported using subjects within geophysics, paleontology, planetology, soil science, and other subdisciplines within geoscience in five out of the eight courses. For the complete summary details see Chapter 5, Table 11.

Table 32

Summary of Academic Subject Areas Covered in Introductory Courses

Course	Specialty Area n=94	Broad Subdivision n=11
Geology Laboratory	20	7
Earth Science & Environment	27	5
Oceanography	22	6
Understanding Earth	32	11
Earth in Action (Geo 104)	33	9
General Geology	27	10
Earth in Action (Geo 106)	26	10
Prehistoric Life	15	3

Quantifying results was not the intent of this qualitative research design as was noted in the delimitations for this study. The small sample size and variety of focus for introductory courses hinder correlation analysis and limit external validity. Several general points are of interest to note, however coincidental these conclusions may be. First and foremost, these findings demonstrate the variety of subject areas and the interdisciplinary nature of topics that these participants reported as important to include in their courses. Second, the participant who labeled himself as an interdisciplinary scholar reported covering the widest range of subject areas; while the participant who labeled himself as a micropaleontologist reported covering the most narrow range of subject areas. Third, the participant who had the longest teaching career, 40 years, and who taught the most specialized introductory course, reported covering the most narrow range of subject areas. There was no noticeable pattern among the other participants whose teaching careers ranged from 2 years to 14 years; while the participants who had taught from 6 to 14 years each reported subjects in 11 of the subdivisions, of the two participants who had taught 2 years each, one covered 8 subject subdivisions and the other, 12 subject subdivisions.

Thus, the value of the first research question was in identifying subject areas participants used and recognizing the interdisciplinary nature of these introductory courses. For example, when a participant assigned the topic of global warming for class debates, students had to consider the human impact on the natural world and its significance, which could bring in information from the realm of politics and economics, as well as a geoscience perspective. This was true for the introductory courses with an environmental emphasis. The introductory course on prehistoric life brought in the topic of evolution and although it was presented from the geoscience perspective, biological topics were introduced as well.

These findings regarding the interdisciplinary nature of geoscience fields of study affirm what was reported in the literature by researchers such as Pruett (1986a), who published a description of the geosciences. An additional value of the overall results to the first research question was that the participants' responses helped to understand projected information outcomes and perceived information needs.

Research Question Two: Resource Types and Formats

Used in Course Development and Instruction

Resource types and formats were determined from interviews, document review, and observations. After the initial list was created by coding interviews and documents, participants reviewed and expanded the list. Eventually the terms were divided into resource types and instructional media formats used to enhance teaching and instruction. Items were added to the list after classroom observations, for a total of 25 resource types and 8 instructional media formats. See Table 33 for a summary. For a complete summary of resource types and instructional media details, see Chapter 5, Tables 30 and 31.

Every participant reported using reference and textbooks, figures-animations-cartoons, websites, and colleagues. Six participants out of seven total indicated they used maps, fossil specimens, and demonstrations; while, five participants reported they used rock and mineral specimens, digital images, and audio-videos sources (e.g., videos). Four participants noted the globe was a useful resource they took into the

Table 33

Summary of Resource Types and Formats Used in Introductory Courses

Course	Resource n=25	Instructional Media n=8
Geology Laboratory	14 used/9 wished for	1
Earth Science & Environment	15 used/9 wished for	3
Oceanography	15 used/9 wished for	3
Understanding Earth	14 used/0 wished for	3
Earth in Action (Geo 104)	20 used/5 wished for	4
General Geology	14 used/0 wished for	3
Earth in Action (Geo 106)	11 used/1 wished for	4
Prehistoric Life	11 used/0 wished for	2

classroom, while four mentioned journals, which was qualified as a source used to keep current and not used directly for introductory course development or instruction. Three participants reported print photographs, photographic slides, Internet data, museums, and hallway displays. Although mentioned, the resources that were used the least included transparencies, aerial photographs, meteorological data or records, field-trip guidebooks, reprints-preprints, brochures, and seismograms-seismic software.

Instructional enhancing media was restricted not by choice of the participant, rather whatever the university funding has allowed for in the classroom. While five participants used a classroom computer to access their images and Internet, these same participants used the computer projection system to deliver lectures through power point presentations. The other two participants in the study did not have the computer projection capability in the rooms they were assigned. Thus, they used the overhead projector and transparencies, as well as colored chalk for the chalkboard text and drawings. Three of the participants used WebCT or Blackboard, while another participant had an extensive online course webpage without password protection. One participant was using e-instruction through clicker devices and one relied upon campus television broadcasts.

Quantifying results was not the intent of this qualitative research design as was previously noted, because the small sample size and variety of campus facilites hinder correlation analysis and limit external validity. Several general points are of interest to note. First and foremost, findings demonstrate the use of instructional enhancing media was directly related to the possibilities available to the participants in the assigned classrooms. In other words, when computers were in the classroom, participants used the variety of technologies available; when computers were not available participants used chalkboard and overhead projections. Thus, inadequate instructional enhancing media was an external barrier for the participants, although there were some exceptions. In three instances, the ELMO projection device was available but not used. One participant cited no interest in using the device, while the other two participants cited poor quality of projection as the reason for not using the ELMO.

The second general finding was that use of enhancing media seems to be less a factor of career stage and more a factor of availability and preference with the exception of the 40 year veteran teacher. Although the participant who had the longest teaching career mentioned he was close to retirement, he made the point that the media to enhance teaching, such as webpages or password protected online systems, the ELMO projection, or the clicker device, were of little value to him because he preferred not to learn to use them. In contrast, of the two newest participants to teaching, one used the most instruction enhancing resources, and the other used the least. However, this was directly related to available equipment and not preference and desire. Thus, career stage does not seem to relate to use electronic teaching enhancement media, as much as availability of media to the participant and desirability to learn.

Third, although gray literature status of sources inhibits acquisition in some cases, it appears that access is not problematic for participants. These participants readily sought out sources electronically or by physically visiting bookstores, public or government survey libraries. One participant used the textbook publishing vendor for the e-instruction device, while others arranged for a satellite link and real-time data monitoring or record acquiring through the Internet. Although few resources preferred by participants were found in their academic libraries, other facilities and means were successfully navigated by participants to look for and gather sources.

Thus, the value of the second research question was in identifying resource types and formats important to course development and instruction. Participants used some sources that could be found in academic libraries, such as reference books and journals, as well as gray literature obtained elsewhere. Although the two participants who taught the introduction with an environmental focus, were often looking for timely resouces they satisfied their information needs with personal journal subscriptions, as well as browsing bookstores, geology survey libraries, and online. In contrast, their students had difficulties finding and judging appropriate media sources to use in assignments; one participant reported his frustration with the lack of peer-reviewed sources the students found to complete assignments. The participants mentioned loaning students sources from their personal collections. Thus, these research findings affirmed previous research about gray literature by researchers such as Bichteler (1991) and Hallmark (1994, 1999) on the problematic nature of locating these resources. However, it was not the participants, but the students who were unable to navigate the maze of facilities and systems beyond their academic library needed to locate geoscience resources. These finding show participants were capable of navigating needed sources for obtaining information, but students in the introductory classes, who relied upon their academic library were not successful in obtaining information. Additionally, participant responses helped to understand information behaviors or the strategies they used to seek and gather information.

Research Question Three: Information Preferences and Barriers

The third research question was related to information preferences, concerns, and barriers of participants in course development and instruction. What emerged was not only a preferred pattern to developing course and instruction, but various contextual factors that interacted and intervened, which were shown in Figure 11.

Proposed information outcomes led to recognition of information needs, some of which were immediately satisfied through participants' expertise that varied with internal contextual factors such as educational specialty backgrounds and career stage. The recognition that developing and satisfying learning and information outcomes and needs goes beyond the participant's expertise resulted in a variety of information behaviors, which were focused on identifying and gathering desired sources and instructional techniques consistent with media available in classrooms. External contextual factors impacted information behaviors and the projected information outcomes, which were described based on previous experiences in teaching the course.

Finally, in considering the results of this study of the role of information in support of teaching and the contextual factors regarding geoscience participants and geoscience sources, what emerged from the data was that participants' academic libraries and librarians played a minor to no role in curriculum or course development and instruction in support of teaching introductory courses. When participants' did not mention academic libraries, the researcher specifically asked participants about their use of library and librarian liaisons. Participants had the perception that their academic libraries had little to offer to enhancing teaching sources, and participants reported the library liaison was the person who ordered books or brought a list of "potential" journal cancellations, which were always cancelled.

For the most part, participants neither encouraged nor discouraged their students in using the academic library for geoscience media assignments, but taught by example. These participants showed students appropriate Internet sources by visiting the university and government sites during class lectures. However, one participant expected students to gather information for geoscience related assignments from peer-reviewed journals and this was problematic. Up-to-date resources were often found in the geoscience participants' offices or reading room for majors, and not readily available to the introductory student who looked to the academic library. If librarians knew participants' expectations for introductory students, then appropriate sources or databases needed to access the information might be located.

While the researcher asked for participants' ideal system to inform them on course and teaching related sources, the question was met with confusion and no readily provided answer. Some believed more sources online would be useful, while one participant described himself as an ideal system with is extensive collection and experiences. While some reminesced about geoscience libraries they had access to in the past, participants seemed content to accept that their current academic library did not have a geoscience branch, was experiencing funding constraints, and could not serve everyone equally. Many had established interpersonal networks or electronic access to sources and merely bypassed their academic libraries.

Thus, what emerged from these research questions was that participants began with a cognitive approach to course development, thinking about personal goals and expectations and focusing on information needs to satisfy projected information outcomes. The first research question revealed the breadth of coverage for the broad or specific introduction to the geosciences that each participant taught. The interdisciplinary approach in geoscience was obvious. The second research question revealed some of the sources and resource formats participants relied upon and expected their students to do likewise. The researcher was expecting a high reliance on gray literature sources needed to enhance instruction and a number of barriers to awareness, access, and acquisiton. The reality was that only one researcher identified the sources as gray literature and problematic, while other participants made no comments on the difficulty of finding and obtaining sources. However, they were frustrated when students did not obtain appropriate sources for assignments. Participants assumed an internal approach, relying on their expertise to select subject areas that best conveyed aspects of the geosciences, a discipline all participants called interdisciplinary by nature which created problems for students more than these participants.

A sequence of course development and instructional practice came from data in response to the research questions. The core information events for sense-making were projected information outcomes, perceived information needs, and strategic information behaviors; while, the core approach through a constructivist perspective to course and instruction was to think through goals and expectations, select representative subject areas, and gather the sources needed to convey the work of geoscientists in advancing the geosciences.

Relationship to Theoretical Framework

This study was framed theoretically in constructivism and sense-making. Sense-making is premised on the notion that people create meaning through interacting with others (Dervin, 1976), while constructivism was described by Littlejohn (1999) as process theory to explain mechanisms communicators use to produce and convey information (p. 107). People who view education through a lens of constructivim and sense-making, realize individuals construct meaning by filtering through personal beliefs, which have social origins learned through interaction with other people. While the geoscience participant is steeped in the culture of the discipline, the student is not. The interaction gained on field trips among geoscientists would provide a deeper appreciation and understanding, but this was not always possible given the large class sizes and limited class times. Thus, the researcher recoreded and observed how participants conveying an understanding of geoscience content and culture to the student in a classroom through course content and innovative instruction. Participants brought specimens to class or electronically took students to the field via digital images or through Internet sites that monitor and record nature.

A disappointment for these participants was that students often come into class with weak science backgrounds and thus, course subject matter may be too far outside the learners' past experiences. To make connections with topics and processes, students need to see how geoscience is significant in their lives. Kelly (1955a; 1955b) advocated a constructivist approach whereby classical lecture and teaching demonstrations were replaced through student learning; students assume part to represent someone who is deeply involved in the problem being studied. One participant included student debates during class time, where a geoscience topic is given, students gather background information and at a later date, students took opposite sides in an open class forum. Another example of a constructivist learning experience was the participant who assigned the seismic activity using a computer software program where students take on the role of geoscientist and must determine the origin of a similated earthquake.

In addition, a constructivist and sense-making methodological approach was used to view geoscience educators and the direct contact with participants had an impact on these participants. The face-to-face exchange between participant and researcher created an awareness of the latent potential of the library and librarian to enhance course development and instruction for some. One participant said he would take his syllabus to the librarian to see what resources might be available and invite a librarian to his introductory course the next semester to inform students of appropriate and available resources for class assignments that could be found in the academic library or elsewhere. In addition, he stated he needed to be proactive and engage the library in obtaining enhancing media and sources rather than merely bypassing the library. Another participant reported she would make inquiries with an academic librarian regarding awareness and acquisition of appropriate course videos.

Thus, what emerged from the data was that these geoscience participants applied a constructivist and sense-making approach to teaching and researching alike. A combination of intrapersonal and interpersonal knowledge and information is the process of educating through a sense-making experience of *being there, storytelling,* and *living together* that Force (2000) attributed to geoscientists and described in his dissertation where he was a participant-observer on a geology field excursion.

Geoscientists approached education similar to the way they approach field research, by employing physical or virtual field trips, hands-on activities, and rich analogies for sense-making and sharing an understanding of some aspects of the nature of the geoscience discipline with others.

Although LIS researchers conduct user studies to better serve their clients, studies that seek to measure the use of information sources and services are constrained by the sources and services offered by the library. Through a constructivist-sense-making lens, user studies seek to investigate the information needs and behaviors of information users. As such, this research was conducted in the natural setting of the geoscience participant and sought to investigate and observe information needs and behaviors in support of teaching through the viewpoint of the participant.

Relationship to Information Needs and Behaviors Models

Dervin's (1992) sense-making methodology and results from a pilot study prompted the research questions which were designed to investigate information needs and behaviors. Contextual factors were expected based on existing LIS models. Wilson and Walsh (1996) argued that information need was a subjective, individual experience and without a clear understanding of need, information-seeking behaviors were difficult to determine. This point highlights the relevance of identifying contextual factors that interact and intervene with both information needs and behaviors; although a pattern of events and approaches can be proposed, relevant contextual factors must be considered. Contextual factors help and hinder the person's progress in satisfying information needs or in experiencing successful information-seeking and outcomes. Thus, this researcher investigated the geoscience participant's teaching role and work task of course development and instruction planning, which led to a pattern of information events, approaches, actions, and contextual factors. Models created by Dervin (1992), Kuhlthau (1993), Foster (2004), Wilson (1981), Wilson and Walsh (1996), and Leckie et al. (1996) were initially reviewed for their rich detail and universal applicability and will now be compared with the findings of this research.

A simple model of a geoscience participant's information world can be seen in Figure 10. This model includes relationships among the three-fold set of information events, a second three-fold set of information approaches, and the six-fold set of actions; taken together these components may demonstrate the role of information to support teaching through course development and instruction. The pattern shows similarities with each of the six LIS models.

Core information events practiced to advance teaching include information needs, behaviors, and outcomes, which were affirmed by Dervin's (1992) sense-making model that predicted a sequence for an information dilemma of situation-bridge-outcome or: (a) needing to situate the dilemma, (b) seeking to bridge the dilemma through search behavior, and (c) using the outcome to satisfy the dilemma. For this study, information needs were identified by focusing on the situation of an introductory curriculum that would serve both majors and non majors. Once information needs were determined, seeking sources for various introductory geoscience courses defined information behaviors. Sources found were used to relate information to students, satisfy information outcomes, project outcomes and needs for the next session.

In addition to the core information events, participants displayed three core processes to course design with determining information goals, subject areas, and resources. Together, the information events and processes were similar to other LIS models. Research findings were affirmed with the Leckie, Pettigrew, and Sylvain (1996) model for information-seeking behavior with an event-process sequence to depict people in service professions who define, identify, and seek information for a role-task-outcome. Wilson's (1981) diagram of the information user predicted need, seeking, and use of information through an information exchange-transfer-outcome sequence; while, Wilson and Walsh's (1996) model for information behavior showed information need activated information-seeking, which activated an information processing and use outcome.

Although the models by Kuhlthau and Foster varied from the pattern created by participants of this study, there were some similarities. Foster's (2004) non-linear model of information-seeking behavior illustrated information seeking with an iterative triad of opening-orientation-consolidation, while Kuhlthau's (1993) ISP model predicted intiation, selection, exploration, formulation, collection, and presentation. Similarities exist among opening, orientation, and consolidation to participants' goals, subject areas, and resources, while the actions in the simple model include thinking or initiation, focusing or formulation, selecting or selection, seeking or exploration, gathering or collection, using or presentation.

In this study, besides core events, processes, and actions, the cognitive, internal, and external approach categories, as well as internal and external contexual factors resulted. Foster's (2004) non-linear model of information-seeking behavior actually nested a *cognitive approach* to information seeking inside a box of *internal context* that was inside a box of *external context* (p. 232). Foster's model resembled Wilson's (1981) model and Wilson and Walsh's (1996) model that nested the *person* inside a box of *role* inside a box of *environment* (p. 8). Although Leckie et al.'s (1996) and Kuhlthau's (1994) models assumed a linear progression, such that service professionals or students are given a task or assignment and this advances a need for sources; in these models, contextual features were not nested but each cascading into the next. In this study, participants' cognitive approach was affected by the external-student contextual factors, while the internal approach was affected by the internal-participant background. Finally the external approach was affected by the external-university contextual factors.

Wilson (1997b) insisted a model of information-seeking must take into consideration "factors that give rise to an individual's perception of a need, the factors that affect the individual's response to the perception of a need, and the processes and actions involved in that response" (p. 39). Numerous factors have been proposed by the information professionals that fall into broad categories such as demographics and personal attributes. Some of these contextual factors proposed by Leckie et al. (1996) and Foster (2004) were common to the participants in this study. For instance, geoscience participants appeared to be effected by professional specialization, prior experience, career stage, time and source constraints from demographic category. Foster's cognitive approach or personal attributes were relevant to these participants including openness of approach, nomadic thinking, adaptable-flexible, holistic, and networking, both social and organizational.

Hence in this research, similarities were found to the six LIS models reviewed and they seemed to affirm research findings. Nevertheless there were only seven participants and further study is warranted.

Conclusions

This research was conducted to investigate geoscience participants perceived information needs and subsequent information behaviors when developing and planning course and instruction for introductory geoscience courses in a university setting. The situational context in academia suggests the theoretical framework of constructivism and sense-making provide a good lens with which to view the participant's role and responsibilities. Various models of information needs and behaviors were reviewed and these exemplary teachers exhibited similarities to the classic LIS models and with interacting and intervening contextual factors.

Information needs were less obvious because the participants were not creating the course for the first time. Needs were more numerous for the geoscience participants newer to teaching than higher ranked faculty who had established considerable personal collections and connections. Barriers and concerns with information-seeking situations were less obvious among participants and more obvious among their students, according to participants. Visual media are the most important sources for teaching for these participants. While nearly all participants have had positive experiences in the past with geoscience specialty libraries, these geoscience educator-participants are bypassing their current academic libraries.

Implications for Library and Information Science

Academic libraries exist to help fulfill the educational mission of universities and may assume a central role with educators when their teaching goals are supported. In order to support or facilitate educators, librarians need to understand the constructivist-sense-making approach of these geoscientist-participants to adequately assist them enhance their teaching.

This research showed that faculty newer to teaching and faculty teaching distance education classes have more information needs, fewer interpersonal connections, and smaller personal collections. While new faculty need more attention from library liaisons, faculty teaching distance classes could benefit from librarian mediation as well. This suggests opportunities for possible collaboration to enhance teaching, especially for new and distance teaching faculty, yet all educators as well.

Librarians should consider promoting networking opportunities because of geoscientist-participants' preference for interpersonal information sources for lectures, demonstrations and activities. Participants not only brought in guests to lecture, physically and electronically, they looked for people from other disciplines when exploring interdisciplinary topics and issues.

Librarians need to reexamine missions and consider student and faculty needs for coursework rather than simply attending to research needs. Although participants mentioned the inconvenience, they successfully navigated the facilities and services beyond their academic libraries to locate needed resources, whether considered gray or mainstream resources; however, students were not as successful. Resources in their academic libraries were too technical, specialized, or out-of-date to be of use for students in introductory geoscience courses.

While these participants depended heavily on personal photographic and digital images, as well as commercial figures, animations, and cartoons, librarians need to provide more visual media. Additionally, participants wanted slide collections converted to digital and librarians need to provide assistance with organizing and formatting existing outdated media formats.

Finally, while librarians are focused on collection development dependent upon purchasing external resources, in an academic context educators and librarians could benefit by collaborative internal collection development. This collaborative collection development approach would enhance teaching through repackaging personal collections of geoscience faculty with attention to the visual media as well as the many unique resource types and formats characteristic of the faculty specialties within geoscience.

The implications of this research extend to those who are not library practitioners. For example, this research suggests that library school educators should provide courses for subject specialty librarianship with a greater emphasis on examining information needs and behaviors of discipline-specific and interdisciplinary communities such as geoscience educators. Additionally, LIS curriculum should prepare practitioners to realize the latent potential of academic libraries, when teaching needs and internal collection development are considered equal in status with research needs and external collection development.

This research fills a gap in the LIS literature on information needs and behaviors of a small community of geoscience educator-participants, taken directly from participants' viewpoints. Additional research may indeed contribute to a better understanding in LIS of this community of scholars and their information world related to teaching, as well as make geoscience educators aware of the opportunities available from academic librarians for mediation and collaboration to enhance teaching. If academic librarians and library school educators want to know how to better serve geoscience educators in support of teaching, then investigating the nature of the discipline and resources, as well as preferences and concerns is essential to gain an understanding of their information needs and behaviors is needed.

Further Research

There is still much to be learned about information uses by diverse communities. A future research study related to geoscientists might focus on academic librarians' perceptions of the information world of geoscience participants and the role of information in support of teaching. Specifically, the researcher will examine the academic libraries associated with these research participants to see similarities or differences among their understanding of the information needs and behaviors in support of teaching for geoscience educators. Additional study will expand to a broader sample of geoscience educators including universities with geoscience specialty academic libraries and librarians. Finally, the researcher will expand the community of information users beyond geoscientists to explore patterns of information needs and behaviors among other academics to explore the *invisible* physical and electronic education network geoscientists appeared to have created in support of their teaching needs.

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APPENDIX A

Geoscience Specialty Teaching and Research Areas
According to the Directory of Geoscience Departments (Keane, 2004, 275).

Subdivisions	Subject Specialty Areas	Percent Reporting*
Geology	General Geology	26%
	Archaeological Geology	
	Environmental Geology	
	Geomorphology	
	Glacial Geology	
	Marine Geology	
	Mineralogy & Crystallography	
	Paleolimnology	
	Petroleum Geology	
	General Petrology	
	Igneous Petrology	
	Metamorphic Petrology	
	Sedimentary Petrology	
	Sedimentology	
	Physical Stratigraphy	
	Structural Geology	
	Tectonics	
	Volcanology	
	Mathematical Geology	
	Mineral Physics	
	History of Geology	
Economic Geology	General Economics	3%
	Coal	
	Metals	
	Non-Metals	
	Oil and Gas	
Geochemistry	General Geochemistry	8%
	Analytical Geochemistry	
	Experimental Petrology/Phase Equilibria	
	Exploration Geochemistry	
	Geochronology & Radioisotopes	
	Low-temperature Geochemistry	
	Marine Geochemistry	
	Organic Geochemistry	
	Stable Isotopes	
	Trace Element Distribution	
Geophysics	General Geophysics	9%
	Experimental Geophysic1427s	
	Exploration Geophysics	

Subdivisions	Subject Specialty Areas	
Geophysics	Geodesy	
	Geomagnetism & Paleomagnetism	
	Gravity	
	Heat Flow	
	Seismology	
	Marine Geophysics	
Paleontology	General Paleontology	7%
	Paleostratigraphy	
	Micropaleontology	
	Paleobotany	
	Palynology	
	Quantitative Paleontology	
	Vertebrate Paleontogy	
	Invertebrate paleontology	
	Paleobiology	
	Paleoecology & Paleoclimatology	
	Geobiology	
Hydrology	General Hydrology	6%
	Ground Water/Hydrogeology	
	Quantitative Hydrology	
	Surface Waters	
	Geohydrology	
Soil Science	Soil Physics/Hydrology	6%
	Soil Chemistry/Mineralogy	
	Pedology/Classification Morphology	
	Forest soils/Rangelands/Wetlands	
	Soil Biology/Biochemistry	
	Paleopedology/Archeology	
	Other Soil Science	
Engineering Geology	General Engineering Geology	3%
	Earthquake Engineering	
	Mining Tech/Extractive Metallurgy	
	Mining Engineering	
	Petroleum Engineering	
	Rock Mechanics	
Oceanography	General Oceanography	8%
	Biological Oceanography	
	Chemical Oceanography	
	Geological Oceanography	
	Physical Oceanography	
	Shore & Nearshore Processes	
Planetology	Cosmochemistry	1%
	Extraterrestrial Geology	
	Extraterrestrial Geophysics	

Subdivision	Subject Specialty Areas	
Other	Meteorites & Tektites	24%
	General Earth Science	
	Atmospheric Science	
	Earth Science Education	
	Physical Geography	
	Ocean Engineering/Mining	
	Remote Sensing	
	Meteorology	
	Material Science	
	Land Use and Urban Geology	
	Geographic Information Systems	
	Not Elsewhere Classified	

*This figure represents the total percent of geoscientists reporting their teaching and research specialty areas to AGI.

APPENDIX B

APPLICATION FOR APPROVAL TO USE HUMAN SUBJECTS

For R&G Use Only	Date approved ________		
File No. ________	Full Review ________	Expedited Review ________	Exempted Review ________

This application should be submitted, along with the Informed Consent Document and supplemental material, to the Institutional Review Board for Treatment of Human Subjects, Research and Grants Center, Plum Hall 313F, Campus Box 4003.

1. Name of Principal Investigator(s) (Individual(s) administering the procedures): **Susan W. Aber**

2. Departmental Affiliation: **School of Library and Information Management**

3. Person to whom notification should be sent: **Susan W. Aber**

   Address: **2002 Holiday Drive, Emporia, KS 66801 6120** Telephone: **620-343-2802**

4. Title of Project: **Information Needs and Behaviors of Geoscience Educators: A Grounded Theory Study**

5. Funding Agency (if applicable): **None**

6. This is a dissertation **X** thesis___ class project___ other

7. Project Purpose(s):
The purpose of this project is to identify geoscience educators' information needs and information-seeking behaviors by exploring the nature of geoscience subject areas, resources, and resource formats and the way they are used to convey geoscience subject matter in curriculum and instruction. The intent is to develop grounded theory on the information world unique to these educators from their viewpoint. Results will serve to lessen the gap between the information world of geoscience educators and the librarian and library school educator's perception of the information world of geoscientists. This may enhance services to library users and curriculum in library schools to better prepare students for librarianship.

8. Describe the proposed subjects: *(age, sex, race, or other special characteristics, such as students in a specific class, etc.)*
Subjects may be any age, sex, or race, and geoscience educators at post-secondary, four-year geoscience degree granting academic institutions. Specifically, six to ten people will be chosen who teach introductory geoscience courses.

9. Describe how the subjects are to be selected:

Purposive sampling will be used to determine participants. Geoscience department chairpersons will be asked to submit names of exemplary geoscience educators who will teach introductory geoscience courses in the summer (July) or fall 2004 semesters. Criteria to determine exemplary university teachers will be described in a formal print letter. Additionally, this will be a sample of convenience, in that the geographic range will be an approximate 150 mile radius of Emporia, KS. The range will be increased if needed.

10. Describe the proposed procedures in the project. Any proposed experimental activities that are included in evaluation, research development, demonstration, instruction, study, treatments, debriefing, questionnaires, and similar projects must be described here. Copies of questionnaires, survey instruments, or tests should be attached. *(Use addition page if necessary.)*
Procedures for data collection include interview, document review, and observation. Data will be gathered through face-to-face, semi-structured interviews. The interview sessions, which will last about one hour, will be audio taped and transcribed. Transcribed copies will be member checked and a form for the participant to sign and provide comments or note changes will be included with the transcript along with a stamped, self-addressed envelope. Interview data will be analyzed with the constant comparative method for emerging themes. Also, data collection will include document review. Documents, such as syllabus and homework or laboratory activities, will be collected and analyzed with classification content analysis, coded according to subject specialty categories published by the American Geological Institute. Additionally, resources and resource formats will be coded according to traditional or gray literature categories. Classifications will be member checked in a second interview session. Finally, semi-structured unobtrusive observations of lecture and laboratory classes will take place, to confirm emerging themes and resource format use, along with a final interview. A copy of questions for initial interviews is attached. No experimental methods will be employed.

11. Will questionnaires, tests, or related research instruments not explained in question # 10 be used? ____ Yes **X** No (If yes, attach a copy to this application.)

12. Will electrical or mechanical devices be applied to the subjects? ____ Yes **X** No *(If yes, attach a detailed description of the device(s) used and precautions and safeguards that will be taken.)*

13. Do the benefits of the research outweigh the risks to human subjects? **X** Yes _No *(If no, this information should be outlined here.)*

14. Are there any possible emergencies which might arise in utilization of human subjects in this project?
____ Yes **X** No *(If yes, details of these emergencies should be provided here.)*

15. What provisions will you take for keeping research data private? *(Be specific.)*
This research approach is qualitative and exploratory, not experimental. Any information collected will be coded, with participants and their academic institutions identified by pseudonyms, which will not be associated with real names and addresses of subjects. Audio taped interviews transcribe and observations, described and coded. Audiotapes will be destroyed once they have been transcribed.

16. **Attach a copy of the informed consent document, as it will be used for your subjects.**

STATEMENT OF AGREEMENT: I have acquainted myself with the Federal Regulations and University policy regarding the uses of human subjects in research and related activities and will conduct this project in accordance with those requirements. Any changes in procedures will be cleared through the Institutional Review Board for Treatment of Human Subjects.

Signature of Principal Investigator Date

Faculty advisor/instructor on project (if applicable) Date

APPENDIX C

INFORMED CONSENT DOCUMENT

Title of Study: Information Needs and Behaviors of Geoscience Educators:
A Grounded Theory Study

Researcher: Susan W. Aber
2002 Holiday Drive, Emporia, KS 66801 6120

The School of Library and Information Management at Emporia State University, Emporia, Kansas, supports the practice of protection for human subjects participating in research. The following is provided so that you can decide whether you wish to participate in the present study. You should be aware that even if you agree to participate, you are free to withdraw at any time. There will be no reproach for choosing not to participate or for withdrawal from the study.

The purpose of this research is to learn more about the information needs and information-seeking strategies of geoscience educators. This study seeks to answer the following research questions:

1. What academic subject areas do geoscience educators use for introductory geoscience curriculums?
2. What resource formats do geoscience educators use in introductory geoscience courses?
3. What are the information preferences, priorities, and concerns of geoscience educators?

Data collection procedures include interviews, document review, and observations. The interviews will take less than one hour and a total of three interview sessions will take place. There will be one or two unobtrusive observations of class sessions and no data will be collected from students in any class under observation.

The benefits of this research include a better understanding of what academic librarians can do to improve collection management and enhance services, as well as what library educators can do to enhance curriculum and better prepare students for librarianship.

"I have read the above statement and have been fully advised of the procedures to be used in this study. I have been given sufficient opportunity to ask any questions I had concerning the procedures. I grant permission to be quoted directly, assuming a pseudonym, and grant permission to be audio taped. I understand that I can withdraw from the study at any time without reproach."

Signature ___________________________ Date ______________________

APPENDIX D

INTERVIEW QUESTIONS

Related to RQ 1:
1. Please tell me about goals and expectations for the introductory geoscience course.

1a. What major subject areas, topics or concepts are needed to provide this understanding of the geosciences?
Probes: Geology, astronomy, oceanography, paleontology, hydrology?

1b. Teaching about Earth can be very broad. What subject areas do you cover outside the geosciences? Please provide examples.
Probes: Biology, chemistry, physics, sociology, economics, architecture?

1d. How would you define your course content, as interdisciplinary? Explain.
Probes: If necessary, define what it means to be interdisciplinary. Foster (2004) defines interdisciplinarity as covering topics where the knowledge domain is related to one or more knowledge domains; or where it appears to be a hybrid subject with no focused, single domain, relying on subdisciplines (p. 230).

Related to RQ 2:
2. Following up on one subject area goal, please tell me about a typical homework or classroom activity you use to convey a certain subject, topic or process to the student.
Probes: How do you present geologic time, plate tectonics, or hydrologic cycle?

2a. What resources and resource formats are used to convey this activity? Please elaborate on any sources or special resource formats you use to enhance the course and instruction; especially applications you rely on beyond the textbook?
Probes: Maps, real-time data, field trips? Or power point, webpage materials?

Related to RQ 3:
3. Please tell me about information preferences, priorities, and concerns for course development or teaching.
Probes: Describe overall where you go to find demonstrations. Could you go back to your homework activity example. What information did you need? What did you have at hand and what additional material did you need?

3a. When you change from one subject area to another, for example, geology to economic geology, does your strategy for finding the necessary information change?
Probe: What barriers hindered completion of this task? What did you wish you had?

3b. Are you aware of a library liaison specific to your department? If so, what services are offered by the library and what services do you use?
Probe: Describe an ideal system for informing you on potential course materials or instruction techniques.

4. Is there anything else that you would like to add to the interview?

APPENDIX E

LETTER TO DEPARTMENT CHAIRPERSONS

25 May, 2004
Dr. XYZ, Department Head
Department of Geoscience
ABC University
City, State

Dear Dr. XYZ,

My name is Susie Aber and I am a doctoral student in the School of Library and Information Management at Emporia State University, Emporia, Kansas. My dissertation research is on the interdisciplinary nature of the geosciences and the information needs of geoscientists. Academic librarians need to know about the geosciences and the information preferences and concerns of geoscientists engaged in exemplary teaching activities and scholarship in order to manage collections and enhance services.

I would appreciate your help to identify exemplary geoscience faculty in your department who teach introductory geoscience courses and who may agree to participate in this study. Researchers define exemplary teachers as ones who excel at clarity and positive classroom conditions, as well as make content relevant by providing examples and connecting course goals to experiences of students. Could you please take a few minutes to provide names of geoscience faculty meeting these effective teaching criteria and teaching introductory geoscience courses, lecture or laboratory sessions, in the 2004 fall semester? The commitment for participants would include: (a) agreeing to three or fewer interviews, each less than one hour in duration; (b) providing documents for review, such as the syllabus and homework or in class activities; and (c) allowing me to observe one to two lecture or laboratory sessions. My proposal abstract is included for additional information.

Thank you so much for your time and quick consideration of this matter. A form and self-addressed envelope are included for your convenience. My email address is email@emporia.edu, if you have any questions or comments you would prefer to communicate electronically.

Sincerely,

Name
Address and Phone Number

Information Needs and Behaviors of Geoscience Educators: A Grounded Theory Study

Abstract

Information use and the information-seeking behavior of scientists and engineers as a whole have been the focus of library and information science research for decades, yet subgroups, such as geoscientists, have rarely been considered in information user studies. The purpose of this study is to identify geoscientists' information needs and information-seeking behaviors by exploring the nature of geoscience subject areas, resources, and resource formats and the way they are used to convey geoscience subject matter in curriculum and instruction. The intent is to develop grounded theory on the information world unique to geoscience educators. A grounded theory methodology with an interpretive approach and naturalistic inquiry will be employed. Data collection methods include in-depth interviews, document review, and observations, while the constant comparative method will be used to analyze data. Results will inform librarians on the geosciences and the ways in which they can enhance services for geoscientists as library and information users. Additionally, results will aid library educators on how to improve library school curriculum to better prepare academic librarians and subject specialists.

Susan W. Aber

Emporia State University

Dissertation Proposal

May 11, 2004

APPENDIX F

LETTER TO POTENTIAL PARTICIPANTS

10 June, 2004
Dr. AAA
Department of Geosciences
ABC University
City, USA

Dr. AAA,

My name is Susie Aber and I am a doctoral student in the School of Library and Information Management at Emporia State University, Emporia, Kansas. I need your help. Dr. XYZ provided me with your name as an exemplary geoscience teacher at ABC University. My dissertation research is on the nature of the geosciences and the information needs and concerns of educators who teach introductory geoscience courses to both majors and non majors. I chose this focus for my dissertation because geoscientists have rarely been considered in information studies by library and information science researchers. There is a tacit assumption that information uses and needs of geoscientists are analogous to other scientists and engineers. You have the unique qualifications and expertise to help address such assumptions. Your input would be extremely valuable and greatly appreciated.

If you choose to participate, I would like to arrange an interview, less than an hour in duration, whenever it is convenient for you. In addition to some questions, I would like to collect for review Geo 100 Introduction to Geoscience course documents, such as syllabus and homework, in class or homework assignments. Another interview would occur around the beginning of the fall semester and dates set for some lecture session observations. After observations, a final interview may occur. Each interview will be less than an hour in duration and my observations would be unobtrusive.

Thank you so much for your time and quick consideration of this matter. I look forward to hearing from you. If you are willing to participate, please read the informed consent document, sign and date one copy, and return it in the self-addressed, stamped envelope. The other copy is for you to keep. My email address is email@emporia.edu and telephone number. If you have any questions or concerns, please contact me.

Sincerely,

Name
Address

APPENDIX G

PARTICIPANT MEMBER CHECK FORM

10 September, 2004

Dr. AAA
ABC University
City, State

Dear Dr. AAA,

Thank you so much for allowing me to interview you on Friday, August 27, 2004. I have conducted and transcribed the interview and have enclosed your copy in this mailing. Could you please take some time to scan the transcript? You could add comments or make changes in the margins if necessary. Please remember this interview was an informal conversation. I examined my notes, listened carefully to the audio recording, and typed the words as accurately as possible. This resulted in less than perfect grammar and incomplete sentences, but that was expected and okay! Please do not take the time to correct informal language or spelling errors unless you feel the intent of your statement is in jeopardy.

Again, thank you for the interview and for taking the time to do this *participant check* of the transcript. It would be a great help to me if you could return the transcript and this page, signed and dated, in a few days. If you have any questions or concerns please contact me at email@emporia.edu or phone number.

Sincerely,

Susie Aber

Please sign this statement and return this page and the transcript in the included addressed and postage paid envelope. Thanks again for your participation and quick response!

_____ I have read the attached transcript of my interview and find my answers to be acceptable as they appear.

_____ I have read the attached transcript and have marked changes that reflect my desired response(s).

______________________________ ______________________________

Signature Date

APPENDIX H

INTERVIEW FACE SHEET AND POST INTERVIEW COMMENT SHEET

Interviewee Name
____

Assigned Code Number
____

Date of Interview
____

Location of Interview
____

Sex
___M ___F
Education degrees:
Undergraduate in ____________________________
Graduate in _________________________________
Graduate in _________________________________
Post Graduate in _____________________________
Work experience outside of teaching
____
____

Current occupational title
____

Number of years teaching experience
___ 1-5 ___ 5-10 ___ 10-15 ___ 15-20 ___ 20-25 ___ 25+

Courses taught in past 2 years
____
____
____

Current research interest
____
____
____

Post interview Comments

APPENDIX I

OBSERVATION FACE SHEET AND POST OBSERVATION COMMENT SHEET

Course Observation Session Instructor's Name

____

Assigned Code Number

____

Date of Observation

____

Location of Observation

____

Resources and Resource Formats Used During Lecture

_____ Maps _____ Rock/Mineral Specimens _____ Fossil Specimens

_____ Photographs _____ Field Trips _____ Power Point Slides

_____ Other

____

____

Post observation Comments

APPENDIX J

DOCUMENT REVIEW PROTOCOL

Course or Lecture Enhancing Resource Types	**Use**	**Wish For**
Maps		
Globe		
Classroom demonstrations		
Power point software		
ELMO projection		
"clickers"		
Web CT or Blackboard		
Rock & mineral specimens		
Fossil specimens		
Museum		
Field trip guidebook		
Government open file report		
Photographic slides		
Print photos		
Digital images		
Animations or cartoons		
Aerial photos		
Rock or ice cores		
Seismograms or software		
Meteorological records		
Geophysical well logs		
Textbooks or reference books		
Preprints or reprints		
Monographs		
Journals		
Colleagues		
Real time data or monitoring		
Brochures		
Internet		
Video or DVD		
Other		

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Susan Ward Aber

Signature of the Author

16 May 2005

Date

INFORMATION NEEDS AND
BEHAVIORS OF GEOSCIENCE EDUCATORS:
A GROUNDED THEORY STUDY

Title of Dissertation

Mary Cooper

Signature of Graduate Office Staff member

5-18-05

Date Received